8 HAZARD TO LIFE

8.1 Introduction

8.1.1 This study determined not only the risk posed by the LPG compound to the new population brought by the proposed Joint User Complex and Wholesale Fish Market, but also the risk posed to the existing population in the vicinity of the LPG compound. The increased societal risk level due to the introduction of population from the Joint User Complex and Wholesale Fish Market was checked if it is within the acceptable level by comparing against the Government Risk Criteria.

(i) Background of the Assessment

8.1.2 The Castle Peak Wholesale Fish Market (CPFM) was originally established at Lo Shu Chau, Castle Peak Bay in 1946 by the Fish Marketing Organisation (FMO). The FMO is a statutory and financially independent corporation founded under the Marine Fish (Marketing) Ordinance, Cap. 291. Owing to the development of Tuen Mun New Town, the Fish Market was temporarily relocated at Area 27 of Tuen Mun (the existing site) in 1973 pending the identification of a suitable site for building a permanent market.

8.1.3 Due to the gradual decay of wooden structures of the current temporary market over 20 years, the lack of parking spaces on the adjacent roads and of hygiene and environmental problems affecting the surrounding land users, the existing FMO wholesale fish market is intended to be relocated at Area 44 of Tuen Mun. The proponent, Architectural Services Department, after extensive consultation, has proposed a development to provide a permanent, combined government complex for Agriculture & Fisheries Department, Home Affairs Department and Marine Department in conjunction with Food and Environmental Hygiene Department (previously, the Regional Services Department, RSD).

8.1.4 A bulk LPG installation already exits in the Area 44 of Tuen Mun and the proposed relocation of the fish market is such that about one-third of it would fall within the 150 m consultation zone of the LPG installation. As a result, a Quantitative Risk Assessment (QRA) study has to be carried out to evaluate the acceptability of the fish market relocation in terms of the Hong Kong SAR Government' s risk criteria. The results of the risk assessment will be compared with the Individual and Societal Risk Guidelines for Acceptable Risk Levels stipulated in:

- ProPECC Practice Note 2/94 on ' Potentially Hazardous Installations' ;
- Chapter 11 of the Hong Kong Planning Standards and Guidelines (HKPSG); and
- Annex 4 of the Technical Memorandum on Environmental Impact Assessment Process (TMEIA).

8.2 Site Description

(i) Site Location

8.2.1 The subject site is located near the opening of the nullah at the northern part of Tuen Mun. It is bounded by the waterfront of the typhoon shelter at the east and Wu Shan

Road at the west. The LPG installation lies due North of the subject site. Figure 8.1 indicates the site location and the surrounding environment**.**

(ii) Joint User Complex and Wholesale Fish Market

8.2.2 The proposed Joint User Complex and Wholesale Fish Market (WFM) development has an area of about 0.88 hectares. The development will consist of 5 storeys and will include facilities such as a wholesale fish market, a community hall, a tent-covered spectator stand on a landscaped deck and other possible community uses.

(iii) LPG Installation

8.2.3 Information related to the LPG installation has been obtained from an earlier QRA report prepared for the Gas Standards Office, EMSD[1]. Briefly, the information is as follows (details may be obtained from the mentioned report):

Properties of LPG

8.2.4 LPG is a mixture of butane (70-80% by volume) and propane. Being heavier than air it is likely to spread closer to the ground in case of a leak. Physical properties of LPG are presented in Table 8.1.

Table 8.1 Composition and Physical Properties of LPG

Parameter	Value
Composition (butane:propane)	75:25 (by volume) 80:20 (by weight)
Molecular Weight (average)	54.5
Gas Density @ 23°C	2.2 kg/m^3
Typical Operating Pressure	4.2 x 10^5 Pa (g)
Lower Flammability Limit	1.9 % (by volume – 0.04 kg/m^3)
Upper Flammability Limit	10 % (by volume – 0.22 kg/m^3)

LPG Storage

Number of storage tanks = 3
Capacity of each storage tank = 10 t

The storage tanks and associated equipment are designed, manufactured and tested in accordance with the requirements of GSO[2].

LPG Delivery

Capacity of delivery tanker = 8 t
Frequency of delivery = 5 per week (once per day in winter)

The tankers are designed and operated in accordance with the standard requirements of both ESSO and GSO[3].

Existing Risk Minimization Measures

For the LPG installation at Tuen Mun Area 44, ESSO have taken all reasonable risk minimisation measures in accordance with the ALARP (as low as reasonably practicable) principle. These include tanks being stress-relieved and 100 % radiographed, tanks and associated equipment being designed, manufactured and tested in accordance with the requirements of GSO[2], two people (driver and assistant) being present during transfer operation, tanker facing away from the storage compound during transfer to enable it to leave the area quickly if needed, all connections, hoses and levels in the storage tanks being checked by the driver before transfer, hose and earthing points being connected, tanks being filled to a maximum of 85 % of their capacities, driver being present close to the emergency cut-off switch while the assistant oversees the discharge, tankers being coated with fireproof material (Chartek III), etc.

(iv) Estimated Population

8.2.5 Population estimates for the area within the 150 m consultation zone of the LPG site have been taken from the report[1]. As there are no residential buildings within 150 m of the LPG installation and because the Urban Clinic and Port Works Depot will not be manned at night, it was assumed that as existing, there will be no night-time population in the vicinity. Approximately one-third of the area of the WFM (including parking) falls within the 150m consultation zone. For the present assessment, however, the fish market population is separated into (a) night time population during fish auction activities (3:00am to 6:30am) and (b) average population figures for daytime operations. Night time traffic densities have been reduced by a factor of 4. The community hall, other possible community uses and associated facilities have been designed to fall outside the consultation zone and can be excluded from the assessment. Table 8.2 shows the population estimates. The population blocks within the study area are shown in Figure 8.3.

Table 8.2 Estimated Population within 150 m of the LPG Installation

Area	Population
Wu Shan Playground	80
Open Space (site of LPG compound)	25
Port Works Depot	6
Promenade	10
Open Space	5
Urban Clinic	193
Road	40
LRT Rail	50
Car Park	16
Bicycle Lane	60
Public Landing Steps	20
Footpath	100
Nullah	10
Joint User Complex and Wholesale Fish Market	147 night-time, 20 daytime

Note: The assumed populations for the Joint User Complex and Wholesale Fish Market are 147 night-time and 20 daytime, the other night-time populations are assumed to be 0.25 of the daytime populations

8.2.6 A spectator stand with a capacity of 1000 has been planned in the proposed Joint User Complex and Wholesale Fish Market for the annual Dragon Boat Festival. Though only a small part of the spectator stand falls within the consultation zone of the LPG installation, it was thought that a sudden influx of this population to the complex may result in some people temporarily falling within the consultation zone. Hence, to account for this and at the same time erring on the side of safety, the entire spectator stand population was also included in the present QRA. However, as this population is likely to be present at the site only once a year (on the occasion of Dragon Boat Festival) the failure frequencies for different scenarios for the spectator stand population has been adopted as 1/365 times those obtained in Sections 8.4.1 to 8.4.4.

(v) Meteorological Data

The Tuen Mun year 1999 meteorological data has been used in the assessment.

- Four wind directions – NE, SE, SW and NW
- Two weather categories – D4 and F2
- By day (0900-1700) and by night (1700-0900)

The wind directions, categories and percentages are given in Table 8.3.

Table 8.3 Wind Directions, Categories and Percentages

Time of Day	Direction	D4	F2
By Day	NE	5.4	0.1
	SE	3.6	0.3
	SW	1.2	0.2
	NW	2.2	0.3
By Night	NE	12.5	26.7
	SE	13.4	12.9
	SW	2.9	6.2
	NW	3.6	8.4

Stability class is a measure of the atmospheric turbulence caused by thermal gradient and indicates the amount of mixing in the atmosphere. Atmospheric stability is categorised into the following six Pasquill stability classes:

Table 8.4 Stability Classes

Class	A	B	C	D	E	F
Definition	Very Unstable	Unstable	Moderately Unstable	Neutral	Moderately Stable	Stable

Neutral condition corresponds to a vertical temperature gradient of approximately 1^{o}C per 100 m.

8.3 Approach to Assessment

8.3.1 Definitions

Hazard
A hazard may be defined as a condition or practice with potential to cause damage, ill health or injury. Alternatively, deviation from normal design standard or operating intent.

Accident
An accident is an unplanned or uncontrolled event, which has led to damage, ill health or injury.

Consequence
A consequence can be simply defined as an outcome of an accident.

Severity
The nature and extent of the consequence is defined as severity. Financial damage or fatality could be an example.

Likelihood or frequency
This is the chance or probability that a hazard may result in an accident and consequence. For example, the likelihood that a seal will fail could be 1 in 100,000 per year based on statistics.

Risk
Pure risk is the likelihood that a hazard will give rise to a consequence with a particular severity in terms of damage, ill health, injury etc. In this assessment the risk is the fatality of one or more people.

Individual Risk
Individual risk is defined as the risk to a member of staff or a member of the public for injury or fatality. For this assessment it is defined as the frequency at which an individual may be expected to be fatally impacted as a result of an accident occurring at the site.

Societal risk
Societal risk is the risk to society by reference to the number of people affected by the range of relevant accidents. Frequency/Number of Fatalities (F/N) curves are used to plot the number of people affected (N) against the cumulative frequency (F) of accidents.

8.3.2 Assessment Criteria

The current risk assessment was based on the Risk Guidelines published in ProPECC PN 2/94, the HKPSG and the TMEIA. These guidelines are:

Individual risk
The Individual Risk Guideline requires that the maximum level of off-site individual risk should not exceed 1 in 100,000 per year or 1 x 10^{-5}/year.

Societal Risk

Figure 8.2 presents the Societal Risk Guidelines for acceptable risk levels. The Guidelines recommend that the frequency of 1, 10 and 100 fatalities must be below 1 x 10^{-3}, 1 x 10^{-4} and 1 x 10^{-5} respectively. Any credible risk of 1,000 or more fatalities is considered unacceptable. Events with a frequency of below 1 x 10^{-9} per year are not considered.

8.3.3 Methodology

For hazard and accident identification, different scenarios are considered. Flammable effects, both immediate and delayed, were considered in the analysis.

Consequence and risk analyses were carried out using the SAFETIMicro (Software for the Assessment of Flammable Explosive and Toxic Impacts) integrated risk package developed by DNV Technica. SAFETIMicro Version 5.23 released in March 2001 was used in the assessment. The software integrates a suite of programs to perform consequence calculations related to release events, it quantifies the resulting hazardous effects and calculates the impact on the local population within the effect zone. The two primary models utilised within SAFETIMicro for the dispersion modelling and population impact calculations are the 'Unified Dispersion Model' (UDM) and 'MPACT'. Meteorological data obtained from the Hong Kong Observatory has also been used in the modelling. Input data and sample calculation files from the 'SAFETI Micro' software are shown in Appendix 8.1 and Appendix 8.2 respectively and Appendix 8.3 shows the frequencies of different weather conditions.

8.4 Hazard Identification

The main hazard in relation to LPG is the escape of gas, which on ignition may result in a fire or an explosion. If not ignited the gas vapours will disperse and get diluted harmlessly. A loss of containment of LPG may occur during delivery, storage or distribution. This section identifies the possible hazards, the failure modes and the possible initiating events causing such a failure.

8.4.1 LPG Transport

An accident involving a LPG tanker on its approach to the LPG compound can cause loss of containment and result in the escape of gas from it. LPG tankers approach the site from Wu Shan Road and Wa Tai Circuit and then access the site along the dedicated access route.

The road tanker failure rates are[4]:

Partial Failure = 5.0 x 10^{-6} per year
Catastrophic Failure = 2.0 x 10^{-6} per year

8.4.2 LPG Transfer from Tanker to Storage Tank

Different scenarios are possible with regards to the release of LPG while being transferred from road tankers to storage tanks. They are discussed below:

Hose Failure

The hose failure is given as[4]:

9.0×10^{-8} per hour

Considering 260 operations per year @ 2h and assuming the probability that such a release will not be limited by the staff (e.g. by turning off the supply) as 0.1,

Failure Frequency = $9.0 \times 10^{-8} \times 2 \times 260 \times 0.1$
= 4.68×10^{-6} per year

Pipework

There is about 40 m of pipework to the three storage tanks downstream of the point of filling. The recommended pipework failure rate[4] is:

1×10^{-6} per metre per year

Thus,

Failure Frequency = $1 \times 10^{-6} \times 40$
= 4×10^{-5} per year

Breakaway

The probability of the driver moving the road tanker during loading is given as[4]:

4×10^{-6} per operation

Considering 260 operations per year, the breakaway failure rate[4] as 0.013 per demand and assuming the probability that such a release will not be limited by the staff as 0.1,

Failure Frequency = $4 \times 10^{-6} \times 260 \times 0.013 \times 0.1$
= 1.35×10^{-6} per year

It may be noted that as the loading arm has been removed from the LPG compound, hence it has not been included in the assessment as a possible failure case.

8.4.3 LPG Storage

The scenarios considered under this category are partial failure and catastrophic failure. As the tanks are entombed, a hot catastrophic failure is not expected.

However, the possibility of failure due to corrosion, poor construction, etc. can not be ruled out.

The storage tank failure rates are given as[4]:

Partial Failure = 5.0×10^{-6} per vessel per year
Catastrophic Failure = 1.8×10^{-7} per vessel per year

As there are three storage tanks, the failure frequencies will be:

Partial Failure = $5.0 \times 10^{-6} \times 3$
$= 1.5 \times 10^{-5}$ per year
Catastrophic Failure = $1.8 \times 10^{-7} \times 3$
$= 5.4 \times 10^{-7}$ per year

Other accidental releases such as overfilling of storage tanks, operator misconnecting the hose, etc. are considered to have insignificant effect on the overall risk assessment and hence have not been considered.

8.4.4 Vaporisers

Liquid LPG would be transferred under its vapour pressure through 50 mm pipework to vaporisers. Taking the vaporiser failure rate[4] to be 1×10^{-6} per metre per year, considering 35 m length of pipework and adopting the failure rate of excess flow valve[4] as 0.13

Failure Frequency = $1 \times 10^{-6} \times 35 \times 0.13$
$= 4.55 \times 10^{-6}$ per year

8.5 Event Trees

8.5.1 The probability of each of the release scenario identified in Section 8.4 above is represented as event trees in Figures 8.4a to 8.4c. The event trees for the spectator stand population are illustrated in Figures 8.5a to 8.5c. Table 8.5 presents the summary of these scenarios and their failure frequencies. Assuming no deliveries at night, incidents involving road tankers were not considered in the night cases.

Table 8.5 Summary of Release Frequencies

Failure Event	Ignition Type	Consequence	Frequency per year	Spectator Stand - Frequency
LPG Transport				
Small	Immediate	Jet Fire/BLEVE*	2.50×10^{-7}	6.85×10^{-10}
	Delayed	Flash Fire	9.50×10^{-7}	2.60×10^{-9}
Catastrophic Rupture	Immediate	Fireball	1.80×10^{-6}	4.93×10^{-9}
	Delayed	Flash Fire	1.62×10^{-7}	4.44×10^{-10}
	Delayed	VCE**	1.80×10^{-8}	4.93×10^{-11}
LPG Transfer				
Coupling/Hose	Immediate	Jet Fire	2.34×10^{-7}	6.41×10^{-10}
	Delayed	Flash Fire	8.00×10^{-7}	2.19×10^{-9}
	Delayed	VCE	8.89×10^{-8}	2.44×10^{-10}
Breakaway	Immediate	Jet Fire	6.75×10^{-8}	1.85×10^{-10}
	Delayed	Flash Fire	2.31×10^{-7}	6.33×10^{-10}
	Delayed	VCE	2.57×10^{-8}	7.04×10^{-11}
Pipework	Immediate	Jet Fire	2.00×10^{-6}	5.48×10^{-9}
	Delayed	Flash Fire	6.84×10^{-6}	1.87×10^{-8}
	Delayed	VCE	7.60×10^{-7}	2.08×10^{-9}
Storage Tanks				
Partial Failure	Immediate	Jet Fire	7.50×10^{-7}	2.05×10^{-9}
	Delayed	Flash Fire	2.56×10^{-6}	7.01×10^{-9}
	Delayed	VCE	2.85×10^{-7}	7.81×10^{-10}
Catastrophic Failure	Immediate	Fireball	4.86×10^{-7}	1.33×10^{-9}
	Delayed	Flash Fire	4.37×10^{-8}	1.20×10^{-10}
	Delayed	VCE	4.86×10^{-9}	1.33×10^{-11}
Vaporisers				
	Immediate	Jet Fire	2.28×10^{-7}	6.25×10^{-10}
	Delayed	Flash Fire	7.78×10^{-7}	2.13×10^{-9}
	Delayed	VCE	8.64×10^{-8}	2.37×10^{-10}

*Boiling Liquid Evaporating Vapour Explosion
** Vapour Cloud Explosion

8.6 Risk Analysis and Results

(i) Risk Integration

8.6.1 The impact and risk posed to the population due to the LPG installation were quantified utilising the MPACT program within the ' SAFETIMicro' software. Two analyses were performed to determine the societal risk of the study area with and without the addition of the population from the fish market. The program summed up the risks in terms of cumulative frequency at any one location (individual risk) using the following inputs:

- *risk sources* for all the release scenarios as determined by the Unified Dispersion Model calculation;

- *consequence* of hazards in terms of distance for each weather category in relation to each release;
- *meteorological data* detailing the different wind directions and stability conditions as shown in Appendix 8.3; and
- *estimated population data* for the regions lying within the consultation zone as shown in Table 8.2

8.6.2 Universal grid references, the surface roughness and the 4 wind direction vectors were incorporated into the integration. Frequencies and consequence ranges for the down-wind and cross-wind scenarios of each event and population distribution were also combined. SAFETIMicro calculates the risk to a hypothetical outdoor individual at that location for 24 hours a day. It takes no account of either shelter or evacuation. The risk of fatalities under each failure scenario was summed up to generate the FN curves for societal risk of the situation with and without the population from the Joint User Complex and Fish Market. FN curve was also obtained for the spectator stand population.

(ii) Results

Individual Risk

8.6.3 The individual risk contours for the 150 m consultation zone around the LPG installation range from 1 x 10^{-6} to below 1 x 10^{-8} as shown in Figure 8.6. The 1 x 10^{-6} risk contour is basically confined to the LPG facility, whereas the 1 x 10^{-8} risk contour passes through the portion of the fish market that falls within the consultation zone. Thus individual risk level for all the populated areas within the consultation zone is less than 1x10^{-5} per year. The risk that the population in the vicinity of the LPG installation would be exposed to is, therefore, considered to be 'acceptable' according to the Risk Guidelines laid down by the Hong Kong Government.

Societal Risk

8.6.4 The overall societal risk for the study area is shown in Figure 8.7. For the populations assessed, the two FN curves fall within the 'acceptable' societal risk region. The FN curves of the two scenarios, with and without the population from the Joint User Complex and Wholesale Fish Market, are nearly identical. It can therefore be concluded that the incremental change in the overall risk will be minimal. Figure 8.8(i) shows the FN curve for the spectator stand population. The curve lies well within the acceptable region and is at least two orders of magnitude lower than the FN curves obtained above (Figure 8.7). In other words, inclusion of the spectator stand population will have no significant effect on the risk.

Table 8.6 shows the FN pairs for the two scenarios, with and without the population from the WFM. It is apparent that the societal risk in both cases is similar (strictly speaking it is a little higher when the WFM population is included).

Table 8.6 FN Pairs

Without Proposed Development		With Proposed Development	
ΣN	F	ΣN	F
1	1.03E-06	1	1.04E-06
2	9.39E-07	2	9.45E-07
3	8.47E-07	3	8.53E-07
4	7.14E-07	4	7.20E-07
5	2.85E-07	5	2.97E-07
6	2.27E-07	6	2.66E-07
8	2.01E-07	8	2.40E-07
10	1.80E-07	10	1.94E-07
12	1.61E-07	12	1.64E-07
15	1.43E-07	15	1.46E-07
20	1.35E-07	20	1.37E-07
25	1.23E-07	25	1.25E-07
30	1.22E-07	30	1.22E-07
40	1.20E-07	40	1.20E-07
50	1.19E-07	50	1.19E-07
60	1.17E-07	60	1.17E-07
80	4.91E-08	80	4.92E-08
100	1.42E-08	100	1.43E-08
120	1.19E-08	120	1.22E-08
150	6.41E-09	150	6.52E-09
200	3.06E-09	200	3.08E-09
250	3.77E-10	250	4.95E-10
300	2.77E-11	300	2.77E-11

8.6.5 Another measure of societal risk is the potential loss of life (PLL), which gives the expected number of fatalities per year. It is a measure of societal risk used for assessing contributors to risk. The societal risk ranking for the above two cases is shown in Tables 8.7(a) and 8.7(b). It is noted that the first six events are responsible for about 80 % of the fatalities. Also with the incorporation of the population from the WFM, the increase in PLL is only 2 %.

Table 8.7a Societal Risk Ranking: Without Development

Case Name	Average Fatalities (per year)	% of Total
Transport-Lar	4.91E-06	33.2
StorageTank-CatRup	1.73E-06	11.7
StorageTank-Vaporisers-Dlay	1.57E-06	10.6
Transfer-Pipework-Dlay	1.40E-06	9.5
Transfer-Coupling/Hose-Dlay	1.33E-06	9.0
StorageTank-Partial-Dlay	6.52E-07	4.4
StorageTank-Vaporisers	4.60E-07	3.1
Transport-Lar-Dlay	4.42E-07	3.0
Transfer-Pipework	4.08E-07	2.8
Transfer-Coupling/Hose	3.88E-07	2.6
Transfer-Breakaway-Dlay	3.83E-07	2.6
StorageTank-Partial	1.91E-07	1.3
StorageTank-Vaporisers-Dlay*	1.74E-07	1.2
StorageTank-CatRup-Dlay	1.56E-07	1.1
Transfer-Pipework-Dlay*	1.55E-07	1.1
Transfer-Coupling/Hose-Dlay*	1.47E-07	1.0
Transfer-Breakaway	1.12E-07	0.8
StorageTank-Partial-Dlay*	7.26E-08	0.5
Transport-Lar-Dlay*	4.91E-08	0.3
Transfer-Breakaway-Dlay*	4.26E-08	0.3
StorageTank-CatRup-Dlay*	1.73E-08	0.1
Transport-Sm	0.00E+00	0.0
Transport-Sm-Dlay	0.00E+00	0.0
Total	1.48E-05	

Sm = small; Lar = Large; CatRup = catastrophic rupture
Dlay = delayed ignition, flash fire; Dlay* = delayed ignition, VCE; Rest = immediate ignition

Summary

Different types of failures in order of their decreasing contribution to risk may be summarised as:

Transport – Large	= 5.40E-06
Storage Tanks to Vaporiser	= 2.20E-06
Transfer – Pipework	= 1.96E-06
Storage Tanks – Catastrophic Rupture	= 1.90E-06
Transfer – Coupling/Hose	= 1.87E-06
Storage Tanks – Small	= 9.16E-07
Transfer – Breakaway	= 5.38E-07
Transport – Small	= Negligible

Table 8.7b Societal Risk Ranking: With Development

Case Name	Average Fatalities (per year)	% of Total
Transport-Lar	4.93E-06	32.7
StorageTank-CatRup	1.90E-06	12.6
StorageTank-Vaporisers-Dlay	1.63E-06	10.8
Transfer-Pipework-Dlay	1.40E-06	9.3
Transfer-Coupling/Hose-Dlay	1.34E-06	8.9
StorageTank-Partial-Dlay	6.52E-07	4.3
StorageTank-Vaporisers	4.77E-07	3.2
Transport-Lar-Dlay	4.44E-07	2.9
Transfer-Pipework	4.08E-07	2.7
Transfer-Coupling/Hose	3.93E-07	2.6
Transfer-Breakaway-Dlay	3.88E-07	2.6
StorageTank-Partial	1.91E-07	1.3
StorageTank-Vaporisers-Dlay*	1.81E-07	1.2
StorageTank-CatRup-Dlay	1.70E-07	1.1
Transfer-Pipework-Dlay*	1.55E-07	1.0
Transfer-Coupling/Hose-Dlay*	1.49E-07	1.0
Transfer-Breakaway	1.13E-07	0.8
StorageTank-Partial-Dlay*	7.26E-08	0.5
Transport-Lar-Dlay*	4.93E-08	0.3
Transfer-Breakaway-Dlay*	4.31E-08	0.3
StorageTank-CatRup-Dlay*	1.90E-08	0.1
Transport-Sm	0.00E+00	0.0
Transport-Sm-Dlay	0.00E+00	0.0
Total	1.51E-05	

Sm = small; Lar = Large; CatRup = catastrophic rupture
Dlay = delayed ignition, flash fire; Dlay* = delayed ignition, VCE; Rest = immediate ignition

Summary

Different types of failures in order of their decreasing contribution to risk may be summarised as:

Transport – Large	= 5.42E-06
Storage Tanks to Vaporiser	= 2.29E-06
Storage Tanks – Catastrophic Rupture	= 2.09E-06
Transfer – Pipework	= 1.96E-06
Transfer – Coupling/Hose	= 1.88E-06
Storage Tanks – Small	= 9.16E-07
Transfer – Breakaway	= 5.44E-07
Transport – Small	= Negligible

8.7 Mitigation Measures

8.7.1 Though the FN curves lie in the acceptable region, mitigation measures have been considered to reduce the potential risk to a minimal level. Presence of a "crane free zone" reduces the risk of tank damage due to crane operations at the neighbouring scrap metal yard. Presence of manually operated warning siren instructs people to take shelter timely and thus reduces the risk to lives.

8.7.2 Though the frequency of presence of the spectator stand population at the site is low, in the event of an accident the consequence may be substantial. To minimise the risk, it is proposed that an arrangement be made with ESSO to avoid LPG delivery during the hours when the spectator stand is fully occupied on the day of the Dragon Boat Festival. Such an arrangement will further eliminate all risks related to road tankers (transport and transfer cases). FN curve for the spectator stand population with this mitigation incorporated is shown in Figure 8.8(ii). Figure 8.9 shows the overall FN curve including the spectator stand population with mitigation. The curve lies in the acceptable region and is nearly identical to the one obtained without inclusion of the spectator stand population (Figure 8.7(ii)).

8.7.3 Fire drill exercises shall be organized for the users of the WFM.

8.7.4 Before excavation work is undertaken, the gas company should be contacted to obtain information (drawings, plans) of all gas pipes in the vicinity of the site. Suitable pipe locating devices must be used to locate underground pipes. Hand dug trial holes must then be used to confirm the position of underground pipes. Excavation must be carried out with extreme care following any advice given by the Gas Authority or Gas Company. All workers must be given sufficient guidance about working in the vicinity of pipelines. Detailed information on working safely near pipelines can be obtained from the Code of Practice – Avoiding Danger from Gas Pipes[5].

8.7.5 Reference should also be made to the Code of Practice for the Provision of Means of Escape in Case of Fire (Hong Kong Buildings Department [1997]) and the Code of Practice for Minimum Fire Service Installations and Equipment and Inspection, Testing and Maintenance of Installations and Equipment (Hong Kong Fire Services Department [1997]).

8.7.6 The final design should minimize pedestrian access to the area of podium within the 150m consultation zone of the LPG installation. Areas of plant etc should be concentrated where possible within this zone of the podium to maximize pedestrian uses on remaining areas of the podium.

8.8 Conclusion

8.8.1 This quantitative risk assessment demonstrates that, with mitigation measures in place, the proposed Joint User Complex and Wholesale Fish Market, Area 44, Tuen Mun is considered feasible in terms of hazard to life since the off-site individual risk level of about 1×10^{-7} per year meets the Risk Guidelines laid down by the Hong

Kong Government (maximum off-site risk not to exceed 1 x 10^{-5} per year) and the FN curve lies in the acceptable region of the risk criteria.

8.8.2 In conclusion, there is no unacceptable risk to the proposed development of the Joint User Complex and Wholesale Fish Market associated with the LPG compound at Area 44, Tuen Mun.

References

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