A Review on Risk Levels Associated with LPG Filling Stations in Hong Kong

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Introduction

Background

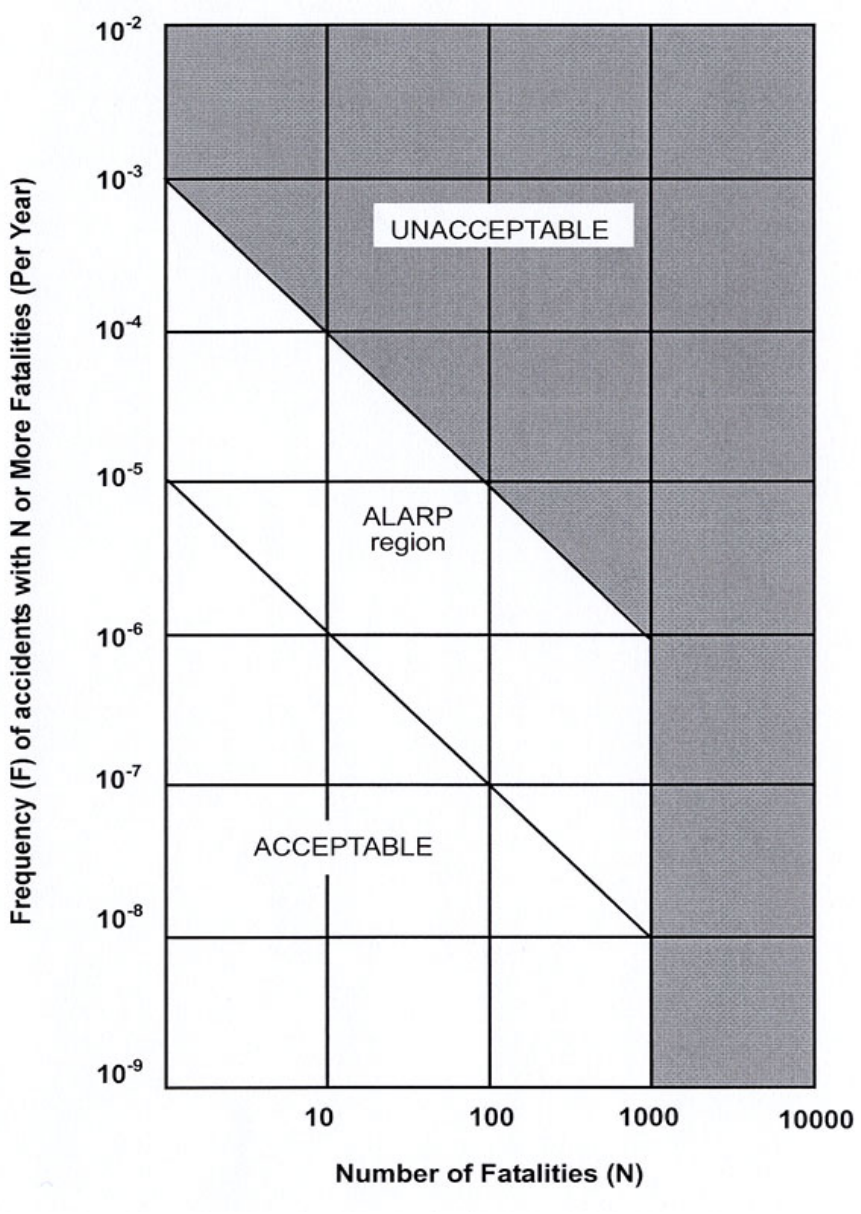
- LPG filling stations have been constructed and operated across Hong Kong since 1998
- LPG filling stations are classified as Notifiable Gas Installation (NGI) in accordance to Gas Safety Ordinance Cap. 51
    - QRA is required to support the NGI construction application

Introduction

Hong Kong Risk Guidelines

- Individual Risk Guideline
  - Maximum level of off-site individual risk should not exceed 1×10^{-5} / year
- Societal Risk Guideline
  - Expressed in terms of fN curve
  - Three areas in the fN curve
    - Acceptable
    - Unacceptable
    - ALARP (As Low As Reasonably Practicable)

Societal Risk Guideline



Objectives

- To identify dominant factors influencing the risk levels of LPG filling stations in Hong Kong
- To compare the planning standards and guidelines for LPG filling stations in Hong Kong

Methodology

- Review QRAs for 17 LPG filling stations
- QRAs were conducted following the methodology employed by the Gas Authority
- Use risk management software SAFETI (Micro v5.3.2)
- Assumptions
  - 90% of LPG road tanker delivery occurs during daytime
  - Nominal population at various locations was input into SAFETI
    - Conservative shielding factors
    - Occupancy factor for working and school population
    - Modification factor for indoor population in instantaneous release events

Methodology

- Potential Loss of Life (PLL) as the end point to compare risk levels among LPG filling stations
- Influencing factors investigated
  - Number of LPG storage vessel
  - Possible maximum amount of LPG release
  - Annual LPG throughput
  - Daytime nominal population around station
  - Night time nominal population around station
  - Separation distance from the station to the closest densely populated location
  - External events

Methodology

- Correlation analysis was applied to determine how strong the influencing factors and risk levels were related

Results (Risk Level and Risk Influencing Factor at Stations)

Stn Code	No. of storage vessels	Max. LPG Release (kg)	Annual Through-put (t)	External Event	Daytime Nominal Pop.	Night-time Nominal Pop.	Distance to the Closest Location with Nominal Population (m)				Potential Loss of Life (per year)
							>50	>100	>500	>1000	
A	1	15000	4437	-	3586.4	1253.8	30	63	93	93	8.45E-5
B	1	14000	5454	-	2010.4	631.9	42	42	114	174	4.15E-5
C	1	10000	3618	Oil Depot Incident	3226.6	540.1	72	72	72	111	3.29E-5
D	1	15000	6507	-	284.7	177.1	60	60	-	-	1.54E-5
E	1	10000	3429	-	275.1	210.4	There are village houses surrounding the station				1.01E-5
F	1	10000	3618	-	231.4	599.0	150	150	-	-	7.63E-6
G	1	15000	900	Landslide	784.1	1241.6	102	102	102	-	6.69E-6
H	2	10000	1593	Landslide	1322.7	4063.0	102	102	150	-	4.78E-6
I	1	15000	360	Aircraft crash	186.3	588.9	175	175	-	-	4.02E-6
J	1	10000	3618	-	527.1	711.7	93	93	93	-	3.51E-6
K	1	13200	4608	Landslide	1195.2	2130.6	110	110	110	-	3.24E-6
L	2	10000	2169	-	1102.8	2050.9	87	87	87	-	2.62E-6
M	1	13200	4059	Landslide	828.7	3186.1	106	106	128	181	2.60E-6
N	1	10000	3618	Landslide	212.0	756.4	165	210	-	-	1.84E-6
O	1	15000	2889	-	782.1	250.5	111	111	168	-	1.43E-6
P	1	15000	8676	Landslide	320.0	429.0	138	138	-	-	7.38E-7
Q	1	9000	2160	Landslide	382.0	594.8	173	173	-	-	3.92E-7

Results (Correlation Analysis)

Risk Influencing Factor	Square of Correlation Analysis (r^2)
Maximum amount of LPG release	0.073
Annual LPG throughput of station	0.043
Daytime nominal population within study area	**0.704**
Night time nominal population within study area	0.011
Reciprocal of distance between station and the closest location with nominal population >50	**0.889**
Reciprocal of distance between station and the closest location with nominal population >100	0.449

Discussion

- Theoretical effect of influencing factor to risk level
  - Maximum LPG release ↑ , risk level ↑ (consequence)
  - Annual throughput ↑ , risk level ↑ (frequency)
  - Population around station ↑ , risk level ↑ (consequence)
  - Separation distance to populated location ↓ , risk level ↑ (consequence)
  - External event present , risk level ↑ (frequency)
  - Risk level of a station is determined by the combined effect of various factors

Discussions

- Observation from the review
  - Two factors appear to pose relatively large influence on predicted risk levels
    - Separation distance from station to the closest location accommodating large population
    - Daytime population around station
  - Other factors did not appear having strong relationship with the predicted risk levels
    - Night time population around station
    - Annual LPG throughput

Discussion

- Observation from the review
  - Effect of External Events
    - Landslide
      - Do not strongly influence the risk level
    - Aircraft crash
      - Seemed to contribute to the risk level considerably when the station is near airfield (aircraft landing/take off point)
      - The influence would depend on the distance to airfield (distance ↑ , influence ↓)

Discussion

- The observations on the influencing factors are limited to the conditions of the 17 LPG filling stations reviewed
- How to avoid unacceptable risk posed by LPG filling station?
  - Allocate station sites away from densely populated areas
  - Allow considerable separation distance from populated location
  - Consistent with relevant planning standards and guidelines

Future Works

- Review more QRAs for LPG filling stations with application of more rigorous statistical analysis technique
- More information concerning influencing factors may help the development of some “rule of thumbs” to facilitate LPG filling site selection in the future

Conclusion

- Investigation on factors influencing risk levels of LPG filling stations
- Factors appeared to have more influent on risk level
  - Daytime population surrounding station
  - Separation distance from populated locations to station

Thank You!