Failure Frequency for Scenarios Associated with Naphtha Storage Tanks

This part includes detailed frequency event calculation used for Naphtha storage tanks in Towngas related calculation including bund scenarios:

Bund Overfilling Scenario

Bund overfilling is envisaged in the case of simultaneous catastrophic rupture of two tanks at TPGPP. Using the approach adopted from the Hazard to Life assessment of the Airport Fuel Tank Farm [23], the failure frequency of the simultaneous failure of more than one tank can be estimated based on individual tank failure frequency. The frequency of leak or rupture of the tank for Catastrophic Rupture is F_{CatRup} = 5E-06/yr. For the existing three storage tanks an independent release from 2 of the tanks would have a frequency of $3F_{CatRup}$ x$2F_{CatRup}$. shows the frequency of failure due to simultaneous failure of 2 tanks at TPGPP. Due to the low event frequency, i.e. less than 1E-9 /yr, the scenario has not been further evaluated in the QRA.

Table 8.9.1 Frequency of Simultaneous Failure of Tanks

Scenario	Frequency (/yr)
Simultaneous Catastrophic rupture of Tanks	1.54E-11

Bund Overtopping Scenario

Another potential scenario that may result in bund overtopping is due to the case of instantaneous release from storage tank unzipping leading to flowing over the bund wall.

In order to model such a scenario of overflow of Naphtha over the bund wall, it is necessary to know the fraction of Naphtha retained within the bund, and that overflows over the bund. Such modelling was performed in the Hazard to Life Assessment for the Permanent Aviation Fuel Facility [24], assessing the percentage of tank content which will remain in the bund for a given bund height, tank filling height and radius from centre of tank to bund wall. Using this methodology, the naphtha tank failure leading bund overtopping is assessed.

Table 8.9.2 Overtopping fraction at TPGPP

Item	Instantaneous tank removal (100% fill level)	Unzipping of tank (100% fill level)
Retained in Bund	82.7%	83.5%
Amount of liquid that overtops	17.3%	16.5%

Bund Overtopping Scenario

To derive the fraction of Naphtha spill overtopping the bund, the following correlation is used [25]:

$$Q = 0.044 - 0.264\ln(h/H) - 0.116\ln(r/H)$$

where Q is the bund overtopping fraction, h is the bund wall height, H in the tank liquid height and r is the distance from the centre of the tank to the bund wall.

The working height of each tank (*H*) is conservatively assumed to be 16.5m, which is the expected maximum. According to the QRA for Ma Tau Kok Gas Plant [13], the height of bund wall (h) can be calculated based on the design volume of the bund as follows:

The effective bund area is estimated to be around 14,280m^2. As the bunded area can hold 110% of the total volume of a tank (40,000 m^3), the height of the bund is calculated to be around 3.1m. The distance from tank centre to bund wall is calculated as 82 m on average.

Table 8.9.3 presents the results of physical modelling for the PAFF assessment for the below mentioned scenarios of bund overtopping, which are also taken into consideration in this study:

- Instantaneous tank removal (100% fill level)
- Unzipping of tank (100% fill level)

Table 8.9.3 Percentage of Tank Content Retained in the Bund as per PAFF Physical Modelling

Instantaneous tank removal (100% fill level)	Unzipping of tank (100% fill level)
75%	73%

Table 8.9.4 presents a comparison in the physical dimensions of PAFF Tanks and Naphtha Tanks at TPGPP.

Table 8.9.4 Comparison of PAFF Tanks and Naphtha Tanks at TPGPP

Description	PAFF	TPGPP
Bund wall height	4.8 m	3.1 m
Distance from tank center to bund wall	30 m	42 m
Height of Tanks(Working level)	25 m	16.5 m
Diameter of Tanks	43.5 m	54 m

Given the above metrics, scaling of metrics needs to be done between PAFF and TPGPP. In doing so, it is possible to estimate the increased or decreased overtopping fraction due to each metric namely Working level (H), bund height (h) and Distance from tank center to bund wall (r).

The Q value for PAFF is 0.4494, while the Q value for TPGPP is 0.3303. This results in a 26.5% decrease in Q value. Thus, the final amount of content retained in the bund after scaling for difference in parameters in PAFF and TPGPP are presented below:

Table 8.9.5 Overtopping fraction at TPGPP

Item	Instantaneous tank removal (100% fill level)	Unzipping of tank (100% fill level)
Amount of liquid that overtops	(1 – 75%) * (0.3303/0.4494) = 18.37%	(1 - 73%) * (0.3303/0.4494) = 19.84%
Retained in Bund	(1 – 18.37%) = 81.63%	(1 – 19.84%) = 80.16%

Diameter of Pool fire formed due to a bund overtopping scenario:

The spill areas have been estimated based on the assumption that, allowing for the rough areas of ground and changes in elevation, the spill outside the bund would be 20cm deep on average. This is in line with the results of the physical tests conducted for the PAFF tank designs [23]. The results for Instantaneous tank removal (100% fill level) and Unzipping of tank (100% fill level) are presented in following tables.

Table 8.9.6 Instantaneous tank removal (100% fill level)

Tank Volume (m3)	Overtopping Fraction	Overtopping Volume (m3)	Pool Area (m2)	Pool Radius (m)
37790	0.1837	6,942	34,710	105

Table 8.9.7 Unzipping of Tank (100% fill level)

Tank Volume (m^3)	Overtopping Fraction	Overtopping Volume (m^3)	Pool Area (m^2)	Pool Radius (m)
37790	0.1984	7,498	37,488	109

Event Frequency for Bund overtopping scenarios

The methodology applied in the PAFF report for assessing the frequency of an instantaneous release from a tank, involved reviewing all the historical catastrophic failure incidents between 1924 and 1995. The derived frequency of instantaneous failure of a tank is taken as 5 x 10^{-9} / yr [24].