1. Cold catastrophic failure of LPG Vessel

1.01E-05

1		
Cold catastrophic failure of LPG		
Vessel (per year)		
3.65E-07		
OR		
2		
Spontaneous failure (per year)		Overfilling (per year)
3.60E-07		4.88E-09
AND		AND
4	5	
Spontanesous failure (per vessel)	No. of storage vessel	Failure of Pressure R
	3	(per demand)
1.80E-07	2	1.00E-04
		Failure of Overfilling
		operation)
		2.00E-02
2 Cold Partial Failure of an IPG Vessel		
1		
Cold Dortiol Epiluro of an LDC Massal		

OR		
2		
Partial failure (per year)		External event failur
1.00E-05		1.00E-07
AND		
5	6	
Partial failure (per vessel)	No. of storage vessel	External event failur
5.00E-06	2	1.00E-07
		AND

Earthquake of modified Mercali intensity (MMI) VII (per year)

1.00E-05







Note: Earthquake/ external impact scenario was considered as a cause of failure for rigid equipment installation, such as piping, and therefore considered for this scenario, with reference to similar past QRA studies [13][28].



11		12)
Overfilling ition)		Staff Fails to Rectify	
		0.2	
	- -		

3. Cold catastrophic failure of LPG road tanker

1		
Cold catastrophic failure of LPG road		
tanker (per year)		
2.25E-07		
OR		_
2		
Spontaneous failure (per year)		Tanker Collisior
4.18E-08		1.83E-07
AND		AND
4	5	
Spontaneous failure (per year)	Portion of time on site*	Tanker collision
		(per operation)
2.00E-06	0.02	1.50E-04

*=(1.5 × no. of tanker delivery)/(24 × 365)

4. Cold Partial Failure of Road Tanker

1		
Cold Partial Failure of Road Tanker		
(per year)		
1.66E-05		
OR		
2		
Partial failure (per year)		Vehicle Impact
1.04E-07		0.00E+00
AND		AND
5	6	
Partial failure (per year)	Portion of time on site*	Vehicle impact
		unloading (per
	0.02	
5.00E-00	0.02	
		Portion of impa
		eneryg to cause
		0.001
		ו טט.טן

*=(1.5 × no. of tanker delivery)/(24 × 365)





	12	1	3
of operation		Portion of impact with sufficient energ	y
year)		to cause damage	
		0.01	
		1	5
		Probability to cause partial failure	

0.9

5. Guillotine Failure of in-let filling pipework

1		
Guillotine Failure of in-let filling		
pipework (per year)		
8.91E-12		
AND		
2		
Failure of in-let filling		
pipework (per year)		
5.26E-06		
OR		
4	5	
Spontaneous failure (per year)	External event failure	Vehicle Impact
	(per year)	(per year)
5.00E-06	1.00E-07	1.65E-07
AND		OR
7	8	
Spontaneous failure of pipework (per m	Length (m)	Impact by tanker
per year)		
1.00E-06	10	1.65E-07
		AND

anker Collision
per visit to storage)
L.50E-04

Probability to have suffic
energy to cause damge

0.01

Note: Earthquake/ external impact scenario was considered as a cause of failure for rigid equipment installation, such as piping, and therefore considered for this scenario, with reference to similar past QRA studies [13][28].



`

	26
Failure of EIS (per demand)	
1.00E-04	
	16
Probability to cause	
0.0	
0.9	
	Failure of EIS (per demand) 1.00E-04 Probability to cause pipeline rupture 0.9

20	
ting	

6. Partial Failure of in-let filling pipework

1		
Partial Failure of in-let filling		
pipework (per year)		
4.33E-09		
AND		
2		
Failure of in-let filling		
pipework (per year)		
3.33E-05		
OR		
4	5	
Partial failure (per year)	External event failure	Vehicle Impact
	(per year)	(per year)
3.30E-05	1.00E-07	1.65E-07
AND		OR
7	8	
Partial failure of pipework (per m per	Length (m)	Impact by tanke
year) [28]		
3.30E-06	10	1.65E-07
		AND

).	01	

1.50E-04

Note: Earthquake/ external impact scenario was considered as a cause of failure for rigid equipment installation, such as piping, and therefore considered for this scenario, with reference to similar past QRA studies [13][28].



9. Guilotine Failure of Flexible Hose during loading to vessel

1		
Guilotine Failure of Flexible Hose during		
loading to vessel (per year)		
5.23E-07		
AND		
2	3	
Leaking during loading (per operation)	No. of filling per year	
6.59E-06	122	
OR		
5		
Hose misconnection		Driver away failure (per operat
(per operation)		
6.00E-06		5.20E-08
AND		AND
9	10	
Hose misconnection	Operator fails to rectify	Tanker drives away
(per operation)	the problem	(per operaation)
3.00E-05	0.2	4.00E-06



	16	17
Manual Valve Failure (per demand)		Excess flow valve failure (per demand)
0.5		0.013
]		
Failure of EIS (per demand)	19	

1.00E-04

10. Partial Failure of Flexible Hose during loading to vessel

Partial Failure of Flexible Hose during loading to vessel (per year)

3.63E-06

AND

Partial Failure (per operation) [28]

5.94E-07

3	4	
No. of filling per year	Failure to isolate leak from tanker	
122	5.01E-02	
	AND	
	5	
	Emergency Isolation System (EIS) is	Manual Valve
	not effective	(per demand)
	0.1001	0.5
	OR	
	8	
	Fail to activate EIS (per demand)	Failure of EIS
		demand)
	0.1	1.00E-04





11. Guilotine Failure of liquid filling line to Vaporizers

1		
Guilotine Failure of liquid filling line to		
Vaporizers (per year)		
6.68E-08		
AND		
2		
Failure of liquid filling line to Vaporizers		
(per year)		
1.03E-05		
OR		
4		
Failure of pipework (per year)		Failure due to vehicle impa
		year)
1.00E-05		1.65E-07
AND		OR
7	8	
Spontaneous failure of pipework (per m	Length of pipework (m)	Impact by tanker
per year)		
1.00E-06	10	1.65E-07
		AND
		Tanker collision (per visit to
		storage)
		1.50E-04

Probability to have sufficient energy to cause damage

0.01



Note: Earthquake/ external impact scenario was considered as a cause of failure for rigid equipment installation, such as piping, and therefore considered for this scenario, with reference to similar past QRA studies

	22	23
Excess flow valve failure (per demand))	Manual Valve Failure
		(per demand)
0.13		0.5
1		
	25	
	25	
Failure of EIS (per demand)		
1.005.04		
1.00E-04		
1		
	16	
Probability to cause nineline runture	10	
Π		

12. Partial Failure of liquid filling line to Vaporizers

1		
Partial Failure of liquid filling line to		
Vaporizers (per year)		
1.66E-06		
AND		
2		
Failure of liquid filling line to Vaporizers		
(per year)		
3.33E-05		
OR		
4		
Failure of pipework (per year)		Failure due to veh
		year)
3.30E-05		1.65E-07
AND		OR
7	8	
Partial failure of pipework (per m per	Length of pipework (m)	Impact by tanker
year) [28]		
3.30E-06	10	1.65E-07
<u> </u>		AND

0.01

storage)

1.50E-04

Note: Earthquake/ external impact scenario was considered as a cause of failure for rigid equipment installation, such as piping, and therefore considered for this scenario, with reference to similar past QRA studies [13][28].



13. Rupture of Vaporizers

	5
	Failure due to vehicle impact (per
	year)
	4.655.07
	1.65E-07
	OR
4	
No. of vaporiser	9
3.00E+00	Impact by tanker
	1.65E-07
	AND
	11
	4 No. of vaporiser 3.00E+00

anker collision (per visit to torage)	
50E-04	
	1
robability to have sufficient	
nergy to cause damage	

0.01



Note: Earthquake/ external impact scenario was considered as a cause of failure for rigid equipment installation, such as piping, and therefore considered for this scenario, with reference to similar past QRA studies [13][28].





Leakage of Booster

umber of Booster compres

Operation Phase

1.00E-04

5.00E-05

kage per compressor per













Operation Phase	Rupture of Booster
1	
Total frequency of equipment full-bore rupture for Booster 2.00E-05	
AND	
2	3
Full-bore rupture of compressor per year	Number of Booster compressor
1.00E-05	2





Operation Phase	Catastrophic Failure of Biogas Holder
1 Total frequency of equipment catastrophic failure for Gas	
Holder	
3.04E-05	
OR	
2	3
Frequency of equipment catastrophic failure for Gas Holder	Hitting frequency of projectile striking from Lindle
3.00E-05	3.80E-07
AND	
4	5
Catastrophic failure of vessel per year	Number of Gas Holder vessel
1.00E-05	3

Operation Phase	Catastroph
1	
Total frequency of equipment catastrophic failure for Dehumidifier	
1.00E-05	
AND	
2	3
Catastrophic failure of vessel per year	Number of
1.00E-05	

Catastrophic Failure of Siloxane Removal

Number of Siloxane Removal

4

nic Failure of Dehumidifier

Dehumidifier vessel









Construction of New West Plant

Catastrophic Failure of Digester

Catastrophic Failure of Biogas Holder

1	
Total frequency of equipment catastrophic failure for Digester	
2.00E-05	
AND	
2	3
Catastrophic failure of vessel per year	Number of Digester vessel
1.00E-05	2

Construction of New West Plant

1	
Total frequency of equipment	
catastrophic failure for Gas	
Holder	
1.01E-05	
OR	
2	3
Frequency of equipment	Hitting frequency of projectile
catastrophic failure for Gas	striking from Lindle
Holder	
1.00E-05	9.50E-08
AND	
-	
4	5
Catastrophic failure of vessel per	Number of Gas Holder vessel
year	
1.00E-05	1









Construction in Existing West Plant Catastrophic Failure of Digester

1	
Total frequency of equipment catastrophic failure for Digester	
3.00E-05	
AND	
2	2
Z Catastrophic failure of vessel per year	S Number of Digester vessel
1.00E-05	

Construction in Existing West Plant

Catastrophic Failure of Biogas Holder

3

1	
Total frequency of equipment	
catastrophic failure for Gas	
Holder	
2.00E-05	
AND	
2	3
Catastrophic failure of vessel per year	Number of Gas Holder vessel
1.00E-05	







0.1