

Appendix 11.5.4

Fault Tree Diagram

1
Cold catastrophic failure of LPG vessel (per year)
Station 1 3.74E-07
Station 2 1.88E-07
Station 3 1.92E-07
Station 4 1.91E-07
Station 5 2.01E-07
Station 6 4.60E-07
Station 7 4.05E-07

OR

2
Spontaneous failure (per year)
Station 1 3.60E-07
Station 2 1.80E-07
Station 3 1.80E-07
Station 4 1.80E-07
Station 5 1.80E-07
Station 6 3.60E-07
Station 7 3.60E-07

AND

4
Spontaneous failure (per vessel)
1.80E-07

5
No. of storage vessel
Station 1 2
Station 2 1
Station 3 1
Station 4 1
Station 5 1
Station 6 2
Station 7 2

3
Overfilling (per year)
Station 1 1.37E-08
Station 2 8.28E-09
Station 3 1.20E-08
Station 4 1.14E-08
Station 5 2.08E-08
Station 6 1.00E-07
Station 7 4.48E-08

AND

6
Failure of Pressure Relief Valve (per demand)
1.00E-04

9
Failure of Overfilling (per operation)
2.00E-02

7
Failure of Pump Overpressurization Protection (per demand)
1.00E-04

10
Staff Fails to Rectify (per demand)
0.2

8
No. of Operations per year
Station 1 343
Station 2 207
Station 3 301
Station 4 285
Station 5 519
Station 6 2501
Station 7 1121

1
Cold catastrophic failure of LPG road tanker (per year)
Station 1 6.32E-07
Station 2 3.81E-07
Station 3 5.55E-07
Station 4 5.25E-07
Station 5 9.56E-07
Station 6 4.61E-06
Station 7 2.07E-06

OR

2
Spontaneous failure (per year)
Station 1 1.17E-07
Station 2 7.09E-08
Station 3 1.03E-07
Station 4 9.76E-08
Station 5 1.78E-07
Station 6 8.57E-07
Station 7 3.84E-07

AND

5
Spontaneous failure (per year)
2.00E-06

3
Vehicle Impact (per operation)
Station 1 3.43E-11
Station 2 2.07E-11
Station 3 3.01E-11
Station 4 2.85E-11
Station 5 5.19E-11
Station 6 2.50E-10
Station 7 1.12E-10

AND

6
Portion of time on site*
Station 1 0.059
Station 2 0.035
Station 3 0.052
Station 4 0.049
Station 5 0.089
Station 6 0.428
Station 7 0.192

7
Vehicle impact into tanker during unloading (per operation)
1.00E-08

10
Portion of impact with sufficient energy to cause damage
0.001

9
Probability to cause catastrophic rupture
0.01

8
No. of operation per year
Station 1 343
Station 2 207
Station 3 301
Station 4 285
Station 5 519
Station 6 2501
Station 7 1121

4
Tanker Collision (per operation)
Station 1 5.15E-07
Station 2 3.11E-07
Station 3 4.52E-07
Station 4 4.28E-07
Station 5 7.79E-07
Station 6 3.75E-06
Station 7 1.68E-06

AND

11
Tanker collision during unloading (per operation)
1.50E-04

12
No. of operation per year
Station 1 343
Station 2 207
Station 3 301
Station 4 285
Station 5 519
Station 6 2501
Station 7 1121

13
Portion of impact with sufficient energy to cause damage
0.01

15
Probability to cause rupture
0.01

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

14
Tanker as the damaged object
0.1

Appendix 11.5.4 -3 Cold Partial Failure of an LPG Vessel

1		Cold partial failure of LPG vessel (per year)	
Station 1	1.01E-05		
Station 2	5.11E-06		
Station 3	5.11E-06		
Station 4	5.11E-06		
Station 5	5.12E-06		
Station 6	1.02E-05		
Station 7	1.01E-05		
OR			
2		Spontaneous failure (per year)	
Station 1	1.00E-05		
Station 2	5.00E-06		
Station 3	5.00E-06		
Station 4	5.00E-06		
Station 5	5.00E-06		
Station 6	1.00E-05		
Station 7	1.00E-05		
AND			
16		Spontaneous failure (per vessel)	
5.00E-06			
17		No. of storage vessel	
Station 1	2		
Station 2	1		
Station 3	1		
Station 4	1		
Station 5	1		
Station 6	2		
Station 7	2		
4		External event failure (per year)	
1.00E-07			
10		Storage vessel failure due to earthquake (per year)	
1.00E-07			
AND			
12		Earthquake of Modified Mercalli Intensity (MMI) VII (per year)	
1.00E-05			
5		Failure of Pressure Relief Valve (per demand)	
1.00E-04			
6		Failure of Pump Overpressurization Protection (per demand)	
1.00E-04			
7		No. of Operations per year	
Station 1	343		
Station 2	207		
Station 3	301		
Station 4	285		
Station 5	519		
Station 6	2501		
Station 7	1121		
8		Failure of Overfilling (per operation)	
2.00E-02			
9		Staff Fails to Rectify	
0.2			
3		Overfilling (per year)	
Station 1	1.37E-08		
Station 2	8.28E-09		
Station 3	1.20E-08		
Station 4	1.14E-08		
Station 5	2.08E-08		
Station 6	1.00E-07		
Station 7	4.48E-08		
AND			
13		Probability of failure due to earthquake	
0.01			

Appendix 11.5.4 -4 Cold Partial Failure of Road Tanker

1	Cold partial failure of LPG road tanker (per year)						
	Station 1	4.66E-05					
	Station 2	2.81E-05					
	Station 3	4.09E-05					
	Station 4	3.87E-05					
	Station 5	7.05E-05					
	Station 6	3.40E-04					
	Station 7	1.52E-04					
OR							
2	Spontaneous failure (per year)						
	Station 1	2.94E-07					
	Station 2	1.77E-07					
	Station 3	2.58E-07					
	Station 4	2.44E-07					
	Station 5	4.44E-07					
	Station 6	2.14E-06					
	Station 7	9.60E-07					
AND							
5	Spontaneous failure (per year)						
	5.00E-06						
6	Portion of time on site*						
	Station 1	0.059					
	Station 2	0.035					
	Station 3	0.052					
	Station 4	0.049					
	Station 5	0.089					
	Station 6	0.428					
	Station 7	0.192					
12	Vehicle Impact (per year)						
	Station 1	3.09E-09					
	Station 2	1.86E-09					
	Station 3	2.71E-09					
	Station 4	2.57E-09					
	Station 5	4.67E-09					
	Station 6	2.25E-08					
	Station 7	1.01E-08					
AND							
15	Vehicle impact into tanker during unloading (per operation)						
	1.00E-08						
16	No. of Operations per year						
	Station 1	343					
	Station 2	207					
	Station 3	301					
	Station 4	285					
	Station 5	519					
	Station 6	2501					
	Station 7	1121					
17	Portion of impact with sufficient energy to cause damage						
	0.001						
18	probability to cause partial failure						
	0.9						
9	Tanker collision during unloading (per operation)						
	1.50E-04						
13	tanker as a damaged object						
	0.1						
10	No. of Operations per year						
	Station 1	343					
	Station 2	207					
	Station 3	301					
	Station 4	285					
	Station 5	519					
	Station 6	2501					
	Station 7	1121					
11	Portion of impact with sufficient energy to cause damage						
	0.01						
14	probability to cause partial failure						
	0.90						
4	Tanker Collision (per year)						
	Station 1	4.63E-05					
	Station 2	2.79E-05					
	Station 3	4.06E-05					
	Station 4	3.85E-05					
	Station 5	7.01E-05					
	Station 6	3.38E-04					
	Station 7	1.51E-04					
AND							

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

1	
Guillotine failure of liquid filling line to vessel (per year)	
Station 1	4.52E-11
Station 2	1.07E-10
Station 3	6.32E-11
Station 4	1.14E-10
Station 5	1.15E-10
Station 6	1.61E-10
Station 7	9.32E-11

AND

2	
Failure of in-let filling pipework (per year)	
Station 1	2.67E-05
Station 2	6.31E-05
Station 3	3.74E-05
Station 4	6.75E-05
Station 5	6.79E-05
Station 6	9.51E-05
Station 7	5.51E-05

OR

4	
Spontaneous failure (per year)	
Station 1	3.40E-06
Station 2	4.00E-06
Station 3	6.00E-06
Station 4	3.60E-06
Station 5	9.60E-06
Station 6	1.80E-05
Station 7	5.00E-06

AND

13	
Spontaneous failure (per metre per year)	
1.00E-06	

3	
**Failure to isolate	
1.69E-06	

5	
**External event failure (per year)	
1.00E-07	

6	
**Vehicle Impact (per year)	
Station 1	2.32E-05
Station 2	5.90E-05
Station 3	3.13E-05
Station 4	6.38E-05
Station 5	5.82E-05
Station 6	7.70E-05
Station 7	5.00E-05

14	
Length (m)	
Station 1	3.4
Station 2	4
Station 3	6
Station 4	3.6
Station 5	9.6
Station 6	18
Station 7	5

3	**Failure to isolate
1.69E-06	
AND	
7	Emergency Isolation System (EIS) is not effective
1.00E-01	
OR	
8	Excess flow valve failure (per demand)
0.013	
9	Manual Valve Failure (per demand)
0.50	
10	Double-check valve Failure (per demand)
2.60E-03	
11	fail to activate EIS (per demand)
0.1	
12	failure of EIS (per demand)
1.00E-04	
5	**External event failure (per year)
1.00E-07	
OR	
15	Pipework failure due to earthquake (per year)
1.00E-07	
AND	
17	Earthquake of Modified Mercalli Intensity (MMI) VII (per year)
1.00E-05	
18	Probability of failure due to earthquake
0.01	

6	
**Failure due to vehicle impact (per year)	
Station 1	2.32E-05
Station 2	5.90E-05
Station 3	3.13E-05
Station 4	6.38E-05
Station 5	5.82E-05
Station 6	7.70E-05
Station 7	5.00E-05

OR

21	
Impact by tanker	
Station 1	4.63E-07
Station 2	2.79E-07
Station 3	4.06E-07
Station 4	3.85E-07
Station 5	7.01E-07
Station 6	3.38E-06
Station 7	1.51E-06

AND

23	
Tanker Collision (per visit to station)	
	1.50E-04

24	
probability for crash into above ground pipework	
	0.001

25	
probability to cause pipeline rupture	
	0.9

22	
Impact by vehicle	
Station 1	2.28E-05
Station 2	5.87E-05
Station 3	3.08E-05
Station 4	6.34E-05
Station 5	5.75E-05
Station 6	7.37E-05
Station 7	4.85E-05

AND

28	
Vehicle impact into pipework (per visit to station)	
	1.50E-04

29	
probability for crash into above ground pipework	
	0.001

30	
probability to cause pipeline rupture	
	0.9

26	
Probability to have sufficient energy to cause damage	
	0.01

27	
No. of Operations per year	
Station 1	343
Station 2	207
Station 3	301
Station 4	285
Station 5	519
Station 6	2501
Station 7	1121

32	
No. of vehicle visiting LPG station (per year)*	
Station 1	166630
Station 2	435080
Station 3	228490
Station 4	469390
Station 5	425955
Station 6	545675
Station 7	359160

31	
Probability to have sufficient energy to cause damage	
	0.001

*No. of vehicle visiting the LPG station (per day)	
Station 1	462
Station 2	1192
Station 3	626
Station 4	1286
Station 5	1167
Station 6	1495
Station 7	984

1	
Guillotine failure of liquid filling line to dispenser (per year)	
Station 1	1.74E-07
Station 2	4.11E-07
Station 3	2.43E-07
Station 4	4.39E-07
Station 5	4.42E-07
Station 6	6.19E-07
Station 7	3.59E-07

AND

2	
Failure of liquid filling line to dispenser (per year)	
Station 1	2.67E-05
Station 2	6.31E-05
Station 3	3.74E-05
Station 4	6.75E-05
Station 5	6.79E-05
Station 6	9.51E-05
Station 7	5.51E-05

OR

4	
Failure of pipework (per year)	
Station 1	3.40E-06
Station 2	4.00E-06
Station 3	6.00E-06
Station 4	3.60E-06
Station 5	9.60E-06
Station 6	1.80E-05
Station 7	5.00E-06

AND

12	
Spontaneous failure of pipework (per year)	
1.00E-06	

5	
**Failure due to vehicle impact (per year)	
Station 1	2.32E-05
Station 2	5.90E-05
Station 3	3.13E-05
Station 4	6.38E-05
Station 5	5.82E-05
Station 6	7.70E-05
Station 7	5.00E-05

13	
Length of pipework (m)	
Station 1	3.4
Station 2	4
Station 3	6
Station 4	3.6
Station 5	9.6
Station 6	18
Station 7	5

6	
*** External Failure (per year)	
1.00E-07	

3	
Failure to isolate	
6.51E-03	

AND

7	
Emergency Isolation System (EIS) is not effective (per demand)	
0.10	

8	
Excess flow valve failure (per demand)	
0.13	

9	
Manual Valve Failure (per demand)	
0.50	

OR

10	
fail to activate EIS (per demand)	
0.1	

11	
failure of EIS (per demand)	
1.00E-04	

Appendix 11.5.4 -6

Guillotine Failure of Liquid Supply Line to Dispenser (Con't)

6	**External event failure (per year)	
	1.00E-07	
14	Pipework failure due to earthquake (per year)	
	1.00E-07	
	AND	
16	Earthquake of Modified Mercalli Intensity (MMI) VII (per year)	
	1.00E-05	
17	Probability of failure due to earthquake	0.01

5
**Failure due to vehicle impact (per year)
Station 1
Station 2
Station 3
Station 4
Station 5
Station 6
Station 7

OR

14
Impact by tanker
Station 1
Station 2
Station 3
Station 4
Station 5
Station 6
Station 7

AND

16
Tanker Collision (per visit to station)
1.50E-04

17
probability for crash into above ground pipework
0.001

18
probability to cause pipeline rupture
0.9

21
Vehicle impact into pipework (per visit to station)
1.50E-04

22
probability for crash into above ground pipework
0.001

23
probability to cause pipeline rupture
0.9

19
Probability to have sufficient energy to cause damage
0.01

20
No. of tanker visiting LPG station (per year)
Station 1
Station 2
Station 3
Station 4
Station 5
Station 6
Station 7

24
Probability to have sufficient energy to cause damage
0.001

25
No. of vehicle visiting LPG station (per year)
Station 1
Station 2
Station 3
Station 4
Station 5
Station 6
Station 7

25
No. of vehicle visiting LPG station (per year)
Station 1
Station 2
Station 3
Station 4
Station 5
Station 6
Station 7

Appendix 11.5.4 -7 Failure of Dispenser

1	Dispenser failure (per year)					
	Station 1	1.14E-03				
	Station 2	1.14E-03				
	Station 3	1.14E-03				
	Station 4	1.14E-03				
	Station 5	1.14E-03				
	Station 6	6.85E-03				
	Station 7	5.71E-03				
	AND					
2	Failure of dispenser (per year)					
	Station 1	8.76E-02				
	Station 2	8.77E-02				
	Station 3	8.77E-02				
	Station 4	8.77E-02				
	Station 5	8.77E-02				
	Station 6	5.27E-01				
	Station 7	4.38E-01				
	AND					
4	Failure of dispenser (per year)					
	Station 1	4.38E-02				
	Station 2	4.39E-02				
	Station 3	4.38E-02				
	Station 4	4.39E-02				
	Station 5	4.39E-02				
	Station 6	4.39E-02				
	Station 7	4.38E-02				
	OR					
5	No. of dispenser					
	Station 1	2				
	Station 2	2				
	Station 3	2				
	Station 4	2				
	Station 5	2				
	Station 6	12				
	Station 7	10				
10	Spontaneous failure of dispenser (per year)					
	4.38E-02					
11	**Failure due to vehicle impact (per year)					
	Station 1	2.32E-05				
	Station 2	5.90E-05				
	Station 3	3.13E-05				
	Station 4	6.38E-05				
	Station 5	5.82E-05				
	Station 6	7.70E-05				
	Station 7	5.00E-05				
3	Failure to isolate					
	1.30E-02					
6	Emergency Isolation System (EIS) is not effective (per demand)					
	0.10					
7	Excess flow valve failure (per demand)					
	0.13					
8	fail to activate EIS (per demand)					
	0.1					
9	failure of EIS (per demand)					
	1.00E-04					

Appendix A-7

Failure of Dispenser (con't)

11		11	
**Failure due to vehicle impact (per year)		22	
Station 1	2.32E-05	Impact by vehicle	
Station 2	5.90E-05	Station 1	2.28E-05
Station 3	3.13E-05	Station 2	5.87E-05
Station 4	6.38E-05	Station 3	3.08E-05
Station 5	5.82E-05	Station 4	6.34E-05
Station 6	7.70E-05	Station 5	5.75E-05
Station 7	5.00E-05	Station 6	7.37E-05
OR		Station 7	4.85E-05
		AND	
21		28	
Impact by tanker		Vehicle impact into pipework (per visit to station)	
Station 1	4.63E-07	1.50E-04	
Station 2	2.79E-07		
Station 3	4.06E-07		
Station 4	3.85E-07		
Station 5	7.01E-07		
Station 6	3.38E-06		
Station 7	1.51E-06		
AND		29	
		probability for crash into above ground pipework	
		0.001	
		30	
		probability to cause pipeline rupture	
		0.9	
		31	
		Probability to have sufficient energy to cause damage	
		0.001	
		32	
		No. of vehicle visiting LPG station (per year)	
		Station 1	168630
		Station 2	435080
		Station 3	228490
		Station 4	469390
		Station 5	425955
		Station 6	545675
		Station 7	359160
		23	
		Tanker Collision (per visit to station)	
		1.50E-04	
		24	
		probability for crash into above ground pipework	
		0.001	
		25	
		probability to cause pipeline rupture	
		0.9	
		26	
		Probability to have sufficient energy to cause damage	
		0.01	
		27	
		No. of Operations per year	
		Station 1	343
		Station 2	207
		Station 3	301
		Station 4	285
		Station 5	519
		Station 6	2501
		Station 7	1121

Appendix 11.5.4 -8a Failure of Flexible Hose during Loading to Underground Vessel (LPG released from road tanker)

[illegible]

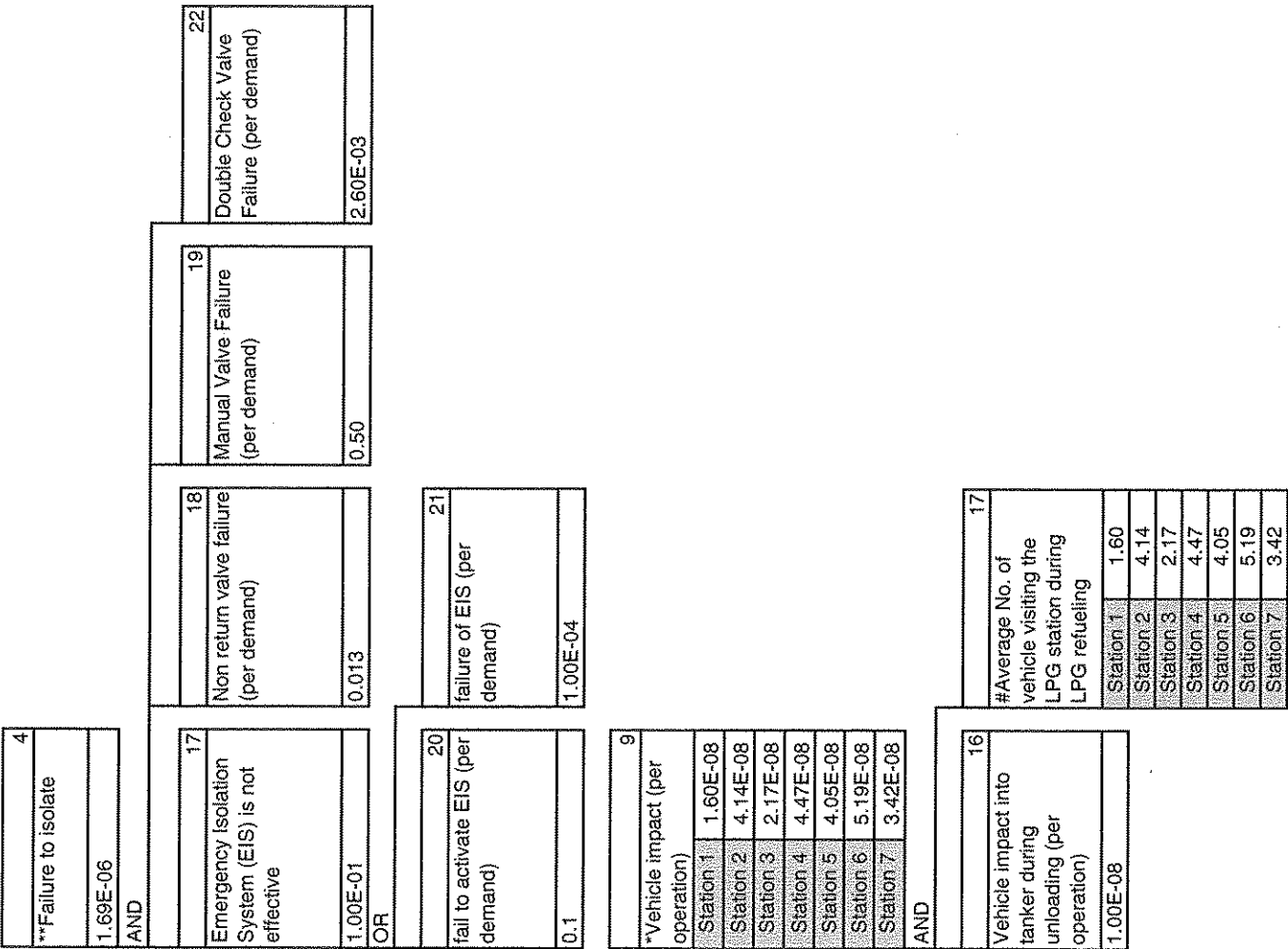
4	
**Failure to isolate	
6.51E-04	
AND	
17	18
Emergency Isolation System (EIS) is not effective	Excess flow valve failure (per demand)
1.00E-01	0.013
OR	
20	21
fail to activate EIS (per demand)	failure of EIS (per demand)
0.1	1.00E-04
	19
	Manual Valve Failure (per demand)
	0.50

9	
*Vehicle impact (per operation)	
Station 1	1.60E-08
Station 2	4.14E-08
Station 3	2.17E-08
Station 4	4.47E-08
Station 5	4.05E-08
Station 6	5.19E-08
Station 7	3.42E-08
AND	
16	17
Vehicle impact into tanker during unloading (per operation)	#Average No. of vehicle visiting the LPG station during LPG refueling
1.00E-08	Station 1
	1.60
	Station 2
	4.14
	Station 3
	2.17
	Station 4
	4.47
	Station 5
	4.05
	Station 6
	5.19
	Station 7
	3.42

=(daily no. of vehicle visit/24 hours) / 60 min x average time of refueling

Appendix 11.5.4 -8b Failure of Flexible Hose during Loading to Underground Vessel (LPG released from storage vessel)

1		Failure during loading (per year)	
Station 1	3.83E-09		
Station 2	2.32E-09		
Station 3	3.37E-09		
Station 4	3.20E-09		
Station 5	5.82E-09		
Station 6	2.81E-08		
Station 7	1.26E-08		
AND			
2		Leaking during loading (per operation)	
Station 1	6.60E-06		
Station 2	6.63E-06		
Station 3	6.61E-06		
Station 4	6.63E-06		
Station 5	6.63E-06		
Station 6	6.64E-06		
Station 7	6.62E-06		
OR			
3		No. of filling per year	
Station 1	343		
Station 2	207		
Station 3	301		
Station 4	285		
Station 5	519		
Station 6	2501		
Station 7	1121		
4		** Failure to isolate leak from tanker	
		1.69E-06	
5		Hose misconnection (per operation)	
		6.00E-06	
AND			
6		Driver away failure (per operation)	
		5.20E-08	
AND			
7		Spontaneous failure (per operation)	
		1.35E-07	
AND			
8		Hose disconnection (per operation)	
		4.00E-07	
AND			
9		*Vehicle impact (per operation)	
		Station 1	1.60E-08
		Station 2	4.14E-08
		Station 3	2.17E-08
		Station 4	4.47E-08
		Station 5	4.05E-08
		Station 6	5.19E-08
		Station 7	3.42E-08
10		Hose misconnection (per operation)	
		3.00E-05	
AND			
11		Operator fails to rectify the problem	
		0.2	
12		Tanker drives away (per operation)	
		4.00E-06	
AND			
13		Breakaway coupling failure (per demand)	
		0.013	
AND			
14		Hose disconnection (per operation)	
		2.00E-06	
AND			
15		Operator fails to rectify the problem	
		0.2	



9

*Vehicle impact (per operation)

Station 1

1.60E-08

Station 2

4.14E-08

Station 3

2.17E-08

Station 4

4.47E-08

Station 5

4.05E-08

Station 6

5.19E-08

Station 7

3.42E-08

AND

16

Vehicle impact into tanker during unloading (per operation)

1.00E-08

AND

17

#Average No. of vehicle visiting the LPG station during LPG refueling

Station 1

1.60

Station 2

4.14

Station 3

2.17

Station 4

4.47

Station 5

4.05

Station 6

5.19

Station 7

3.42

=(daily no. of vehicle visit/24 hours) / 60 min x average time of refueling

Appendix 11.5.4 -9a Failure of Flexible Hose during Loading to Vehicle (LPG released from dispenser)

1	Failure during loading (per year)	Station 1	5.54E-02	Station 2	4.86E-02	Station 3	4.86E-02	Station 4	6.48E-02	Station 5	8.37E-02	Station 6	4.04E-01	Station 7	2.66E-01	AND
2	Leaking during loading (per operation)	Station 1	1.14E-04	Station 2	1.01E-04	Station 3	1.01E-04	Station 4	1.32E-04	Station 5	1.68E-04	Station 6	7.86E-04	Station 7	5.19E-04	OR
3	Vehicles for LPG refueling per year	Station 1	74,825	Station 2	65,700	Station 3	65,700	Station 4	87,600	Station 5	113,150	Station 6	545,675	Station 7	359,160	4
4	** Failure to isolate (per demand)	6.51E-03														5
5	Hose misconnection (per operation)	6.00E-06														6
6	Driver away failure (per operation)	5.20E-07														7
7	Spontaneous failure (per operation)	7.50E-09														8
8	Hose disconnection (per operation)	4.00E-07														9
9	Vehicle impact	Station 1	1.07E-04	Station 2	9.38E-05	Station 3	9.38E-05	Station 4	1.25E-04	Station 5	1.61E-04	Station 6	7.79E-04	Station 7	5.13E-04	AND
10	Hose misconnection (per operation)	3.00E-05														11
11	Operator fails to rectify the problem	0.2														12
12	Vehicle drives away (per operation)	4.00E-06														13
13	Breakaway coupling failure	0.13														14
14	Hose disconnection (per operation)	2.00E-06														15
15	Operator fail to rectify the problem	0.2														16
16	Vehicle impact during refueling (per operation)	1.50E-04														17
17	Average No. of vehicle visiting the LPG station during LPG refueling process*	Station 1	0.71	Station 2	0.63	Station 3	0.63	Station 4	0.83	Station 5	1.08	Station 6	5.19	Station 7	3.42	

4
** Failure to isolate
6.51E-03

AND

18	19	20
Emergency Isolation System (EIS) is not effective	Manual Valve Failure (per demand)	Excess flow valve failure (per demand)
1.00E-01	0.50	0.13

OR

21	22
fail to activate EIS (per demand)	failure of EIS (per demand)
0.1	1.00E-04

* = (daily no. of vehicle visit/24hours)/60min x average time of refilling

No. of vehicle for LPG refuelling (per day)	
Station 1	205
Station 2	180
Station 3	180
Station 4	240
Station 5	310
Station 6	1495
Station 7	984

Appendix 11.5.4 -9b Failure of Flexible Hose during Loading to Vehicle (LPG released from vehicle)

1	
Failure during loading (per year)	
Station 1	5.54E-03
Station 2	4.86E-03
Station 3	4.86E-03
Station 4	6.48E-03
Station 5	8.37E-03
Station 6	4.04E-02
Station 7	2.66E-02

AND

2		3		4	
Leaking during loading (per operation)		Vehicles for LPG refueling per year		** Failure to isolate (per demand)	
Station 1	1.14E-04	Station 1	74,825	6.51E-04	
Station 2	1.01E-04	Station 2	65,700		
Station 3	1.01E-04	Station 3	65,700		
Station 4	1.32E-04	Station 4	87,600		
Station 5	1.68E-04	Station 5	113,150		
Station 6	7.86E-04	Station 6	545,675		
Station 7	5.19E-04	Station 7	359,160		

OR

5	
Hose misconnection (per operation)	
6.00E-06	

AND

10		11	
Hose misconnection (per operation)		Operator fails to rectify the problem	
3.00E-05		0.2	

6		7	
Driver away failure (per operation)		Spontaneous failure (per operation)	
5.20E-07		7.50E-09	

AND

12		13	
Vehicle drives away (per operation)		Breakaway coupling failure	
4.00E-06		0.13	

8	
Hose disconnection (per operation)	
4.00E-07	

AND

14	
Hose disconnection (per operation)	
2.00E-06	

9	
Vehicle impact	
Station 1	1.07E-04
Station 2	9.38E-05
Station 3	9.38E-05
Station 4	1.25E-04
Station 5	1.61E-04
Station 6	7.79E-04
Station 7	5.13E-04
AND	

16	
Vehicle impact during refueling (per operation)	
1.50E-04	

17	
Average No. of vehicle visiting the LPG station during LPG refueling process*	
Station 1	0.71
Station 2	0.63
Station 3	0.63
Station 4	0.83
Station 5	1.08
Station 6	5.19
Station 7	3.42

4	
** Failure to isolate	
6.51E-04	
AND	
18	
Emergency Isolation System (EIS) is not	
1.00E-01	
OR	

21	
Manual Valve Failure (per demand)	
0.50	

22	
Non return valve failure (per demand)	
1.30E-02	

19	
fail to activate EIS (per demand)	
0.10	

20	
failure of EIS (per demand)	
1.00E-04	

* = (daily no. of vehicle visit/24hours)/60min x average time of refilling

No. of vehicle for LPG refuelling (per day)	
Station 1	205
Station 2	180
Station 3	180
Station 4	240
Station 5	310
Station 6	1495
Station 7	984

Appendix 11.5.4-10 Failure to Prevent BLEVE

1	Failure to prevent BLEVE	
	7.50E-04	
	AND	
2	Water spray system failure	
	1.50E-02	
3	Fire Service fail to prevent BLEVE	
	0.5	
4	Chartek Coating fail under jet fire	
	0.1	

Appendix 11.5.4 -11 Leak From Pump Flange

1			
Leak from Pump Flange (per year)			
Station 1	4.36E-04		
Station 2	2.18E-04		
Station 3	2.18E-04		
Station 4	2.18E-04		
Station 5	2.18E-04		
Station 6	4.36E-04		
Station 7	4.36E-04		
AND			
2		3	
Flange Failure (per year)		No. of storage vessel	
1.09E-04		Station 1	2
		Station 2	1
		Station 3	1
		Station 4	1
		Station 5	1
		Station 6	2
		Station 7	2
		4	
		No. of pump flange in a storage vessel	
		2	

Appendix 11.5.4-12 Leak From Drain Valve

1	
Leak from drain valve (per year)	
Station 1	4.80E-04
Station 2	2.40E-04
Station 3	2.40E-04
Station 4	2.40E-04
Station 5	2.40E-04
Station 6	4.80E-04
Station 7	4.80E-04

2	
Valve fails to close (per year)	
Station 1	4.80E-04
Station 2	2.40E-04
Station 3	2.40E-04
Station 4	2.40E-04
Station 5	2.40E-04
Station 6	4.80E-04
Station 7	4.80E-04

AND

3	
Valve fails to close (per operation)	
2.00E-05	

4	
No. of operation per year	
12	

5	
No. of storage vessel	
Station 1	2
Station 2	1
Station 3	1
Station 4	1
Station 5	1
Station 6	2
Station 7	2

Appendix 11.5.4-13 Failure of Vapour Return Line

[illegible]

Appendix 11.5.4-14 Guillotine Failure of liquid line from tanker to loading hose (Con't)

6	
**Vehicle Impact (per year)	
Station 1	3.09E-09
Station 2	1.86E-09
Station 3	2.71E-09
Station 4	2.57E-09
Station 5	4.67E-09
Station 6	2.25E-08
Station 7	1.01E-08
AND	
17	18
Vehicle impact into tanker during unloading (per operation)	No. of Operations per year
1.00E-08	Station 1 343
	Station 2 207
	Station 3 301
	Station 4 285
	Station 5 519
	Station 6 2501
	Station 7 1121
	19
	Portion of impact with sufficient energy to cause damage
	0.001
	20
	probability to cause pipe rupture
	0.9

3
**Failure to isolate
5.01E-02
AND
9
Emergency Isolation System (EIS) is not effective
1.00E-01
OR
10
Manual Valve Failure (per demand)
0.50

11
fail to activate EIS (per demand)
0.1

12
failure of EIS (per demand)
1.00E-04

Appendix 11.5.4 -14 Guillotine Failure of liquid line from tanker to loading hose (Con't)

5	
**Tanker Collision (per year)	
Station 1	4.63E-04
Station 2	2.79E-04
Station 3	4.06E-04
Station 4	3.85E-04
Station 5	7.01E-04
Station 6	3.38E-03
Station 7	1.51E-03
AND	
13	
Tanker collision during unloading (per operation)	
1.50E-04	
14	
No. of Operations per year	
Station 1	343
Station 2	207
Station 3	301
Station 4	285
Station 5	519
Station 6	2501
Station 7	1121
15	
Portion of impact with sufficient energy to cause damage	
0.01	
16	
probability to cause	
0.90	

Appendix 11.5.4-15a BLEVE of LPG road tanker due to fire from petrol filling facilities

1	
BLEVE of road tanker (per year)	
Station 1	5.59E-09
Station 2	3.38E-09
Station 3	4.91E-09
Station 4	4.65E-09
Station 5	8.46E-09
Station 6	-
Station 7	-
AND	
2	
Fire incident from petrol filling facilities (per year)	
Station 1	1.27E-02
Station 2	1.27E-02
Station 3	1.27E-02
Station 4	1.27E-02
Station 5	1.27E-02
Station 6#	-
Station 7#	-
3	
Portion of fire incident which is serious enough to endanger road tanker	
0.01	
4	
Portion of time on site*	
Station 1	0.059
Station 2	0.035
Station 3	0.052
Station 4	0.049
Station 5	0.089
Station 6	0.428
Station 7	0.192
5	
Failure to prevent BLEVE	
7.50E-04	
AND	
6	
Water spray system failure	
1.50E-02	
7	
Fire Service fail to prevent BLEVE	
0.5	
8	
Chartek Coating fail under jet fire	
0.1	

Station 6 & 7 are dedicated LPG station

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

Appendix 11.5.4-15b BLEVE of LPG road tanker due to fire from LPG dispenser

1		BLEVE of road tanker (per year)									
Station 1	2.51E-10										
Station 2	1.52E-10										
Station 3	2.20E-10										
Station 4	2.09E-10										
Station 5	3.80E-10										
Station 6	1.10E-08										
Station 7	4.11E-09										
AND											
2		LPG dispenser failure (per year)		3		4		5		6	
Station 1	1.14E-03			Portion of release become jet fire		Portion of jet fire impinge on road tanker		Portion of time on site*		Failure to prevent BLEVE	
Station 2	1.14E-03			0.05		0.1		Station 1 0.059		7.50E-04	
Station 3	1.14E-03							Station 2 0.035		AND	
Station 4	1.14E-03							Station 3 0.052			
Station 5	1.14E-03							Station 4 0.049			
								Station 5 0.089			
Station 6	6.85E-03									7	
Station 7	5.71E-03							Station 6 0.428		Water spray system failure	
								Station 7 0.192		1.50E-02	
										8	
										Fire Service fail to prevent BLEVE	
										0.5	
										9	
										Chartek Coating fail under jet fire	
										0.1	

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

Appendix 11.5.4-15c BLEVE of LPG road tanker due to fire from In-let Filling Pipework

1	
BLEVE of road tanker	
Station 1	9.96E-18
Station 2	1.42E-17
Station 3	1.22E-17
Station 4	2.09E-17
Station 5	3.83E-17
Station 6	2.58E-16
Station 7	6.71E-17
AND	
2	
Failure of In-let filling pipework (per year)	
Station 1	4.52E-11
Station 2	1.07E-10
Station 3	6.32E-11
Station 4	1.14E-10
Station 5	
	1.15E-10
Station 6	1.61E-10
Station 7	9.32E-11
3	
Portion of release become jet fire	
0.05	
4	
Portion of jet fire impinge on road tanker	
0.1	
5	
Portion of time on site*	
Station 1	0.059
Station 2	0.035
Station 3	0.052
Station 4	0.049
Station 5	0.089
Station 6	0.428
Station 7	0.192
6	
Failure to prevent BLEVE	
7.50E-04	
AND	
7	
Water spray system failure	
1.50E-02	
8	
Fire Service fail to prevent BLEVE	
0.5	
9	
Chortek Coating fail under jet fire	
0.1	

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

Appendix 11.5.4-15e BLEVE of LPG road tanker due to fire from Flexible Hose during loading to underground vessel

1		BLEVE of road tanker (per year)	
Station 1	3.25E-13		
Station 2	1.19E-13		
Station 3	2.50E-13		
Station 4	2.25E-13		
Station 5	7.46E-13		
Station 6	1.73E-11		
Station 7	3.48E-12		
AND			
2		Failure of Flexible Hose during loading to vessel (per year)	
Station 1	1.47E-06		
Station 2	8.93E-07		
Station 3	1.29E-06		
Station 4	1.23E-06		
Station 5			
	2.24E-06		
Station 6	1.08E-05		
Station 7	4.83E-06		
		3	
		Portion of release become jet fire	
		0.05	
		4	
		Portion of jet fire impinge on road tanker	
		0.1	
		5	
		Portion of time on site*	
		Station 1	0.059
		Station 2	0.035
		Station 3	0.052
		Station 4	0.049
		Station 5	0.089
		Station 6	0.428
		Station 7	0.192
		6	
		Failure to prevent BLEVE	
		7.50E-04	
		AND	
		7	
		Water spray system failure	
		1.50E-02	
		8	
		Fire Service fail to prevent BLEVE	
		0.5	
		9	
		Chartek Coating fail under jet fire	
		0.1	

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

Appendix 11.5.4-15f BLEVE of LPG road tanker due to fire from Liquid Line (from tanker to loading hose)

1	
BLEVE of road tanker	
Station 1	9.96E-18
Station 2	1.42E-17
Station 3	1.22E-17
Station 4	2.09E-17
Station 5	3.83E-17
Station 6	2.58E-16
Station 7	6.71E-17
AND	
2	
Failure of Liquid Line from tanker to loading hose (per year)	
Station 1	4.52E-11
Station 2	1.07E-10
Station 3	6.32E-11
Station 4	1.14E-10
Station 5	
	1.15E-10
Station 6	1.61E-10
Station 7	9.32E-11
3	
Portion of release become jet fire	
0.05	
4	
Portion of jet fire impinge on road tanker	
0.1	
5	
Portion of time on site*	
Station 1	0.059
Station 2	0.035
Station 3	0.052
Station 4	0.049
Station 5	0.089
Station 6	0.428
Station 7	0.192
6	
Failure to prevent BLEVE	
7.50E-04	
AND	
7	
Water spray system failure	
1.50E-02	
8	
Fire Service fail to prevent BLEVE	
0.5	
9	
Chartek Coating fail under jet fire	
0.1	

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