1. Cold catastrophic failure of LPG Vessel

1
Cold catastrophic failure of LPG Vessel (per year)
3.65E-07

OR

2
Spontaneous failure (per year)
3.60E-07

AND

4	5
Spontanesous failure (per vessel)	No. of storage vessel
1.80E-07	2

3
Overfilling (per year)
4.88E-09

AND

6	7	8
Failure of Pressure Relief Valve (per demand)	Failure of Pump Overpressurization Protection (per demand)	No. of Operations per year
1.00E-04	1.00E-04	122

9	10
Failure of Overfilling (per operation)	Staff Fails to Rectify (per demand)
2.00E-02	0.2

2. Cold Partial Failure of an LPG Vessel

1
Cold Partial Failure of an LPG Vessel (per year)
1.01E-05

OR

2
Partial failure (per year)
1.00E-05

AND

5	6
Partial failure (per vessel)	No. of storage vessel
5.00E-06	2

3
External event failure (per year)
1.00E-07

AND

7
External event failure (per year)
1.00E-07

AND

13
Earthquake of modified Mercali intensity (MMI) VII (per year)
1.00E-05

4
Overfilling (per year)
4.88E-09

AND

8	9	10	11	12
Failure of Pressure Relief Valve (per demand)	Failure of Pump Overpressurization Protection (per demand)	No. of Operations per year	Failure of Overfilling (per operation)	Staff Fails to Rectify
1.00E-04	1.00E-04	122	2.00E-02	0.2

14
Probability of failure due to earthquake
1.00E-02

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].

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)
4.18E-08

AND

4
Spontaneous failure (per year)
2.00E-06

5
Portion of time on site*
0.02

3
Tanker Collision (per year)
1.83E-07

AND

6
Tanker collision during unloading (per operation)
1.50E-04

7
No. of operation (per year)
122

9
Tanker as the damaged object
0.1

8
Portion of impact with sufficient energy to cause damage
0.01

10
Probability to cause rupture
0.01

*=(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)
1.04E-07

AND

5
Partial failure (per year)
5.00E-06

6
Portion of time on site*
0.02

3
Vehicle Impact (per year)
0.00E+00

AND

7
Vehicle impact into tanker during unloading (per operation)
0.00E+00

8
No. of operation per year
122

9
Probability to cause partial failure
0.9

10
Portion of impact with sufficient eneryg to cause damage
0.001

4
Tanker Collision (per operation)
1.65E-05

AND

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

12
No. of operation (per year)
122

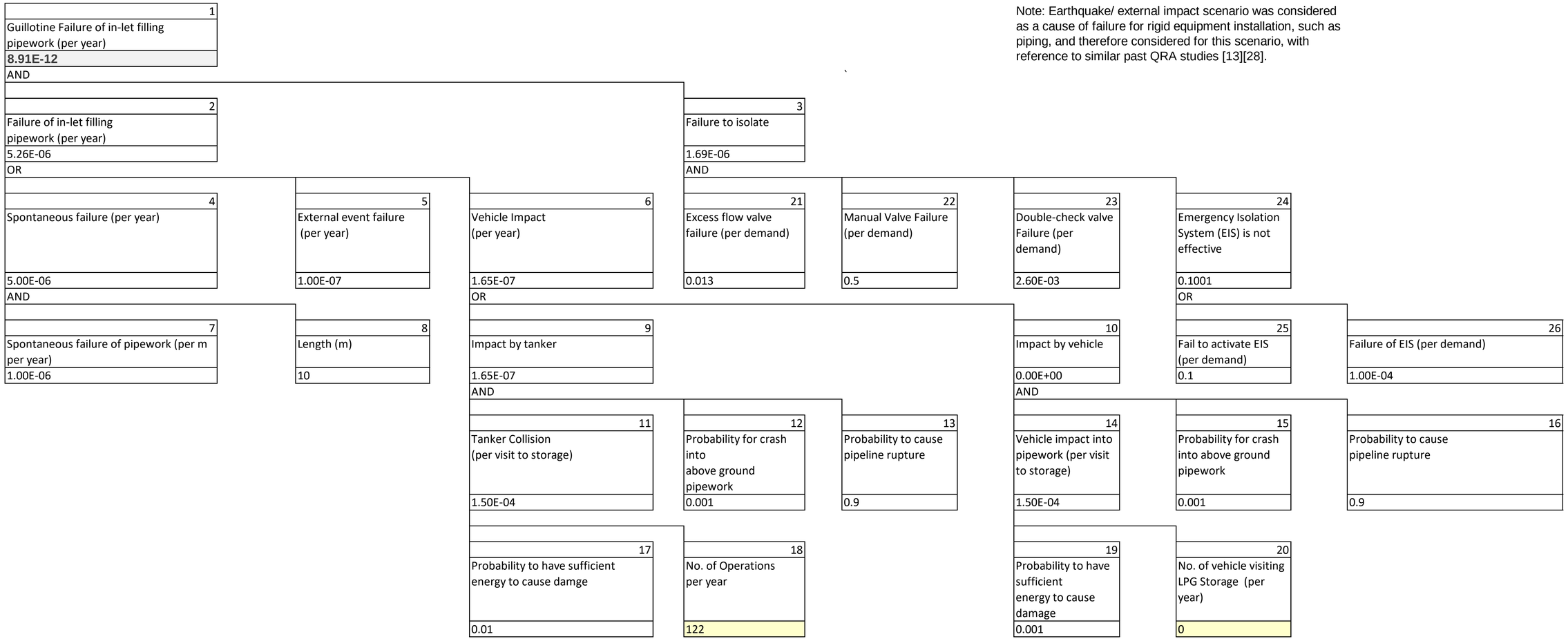
14
Tanker as the damaged object
0.1

13
Portion of impact with sufficient energy to cause damage
0.01

15
Probability to cause partial failure
0.9

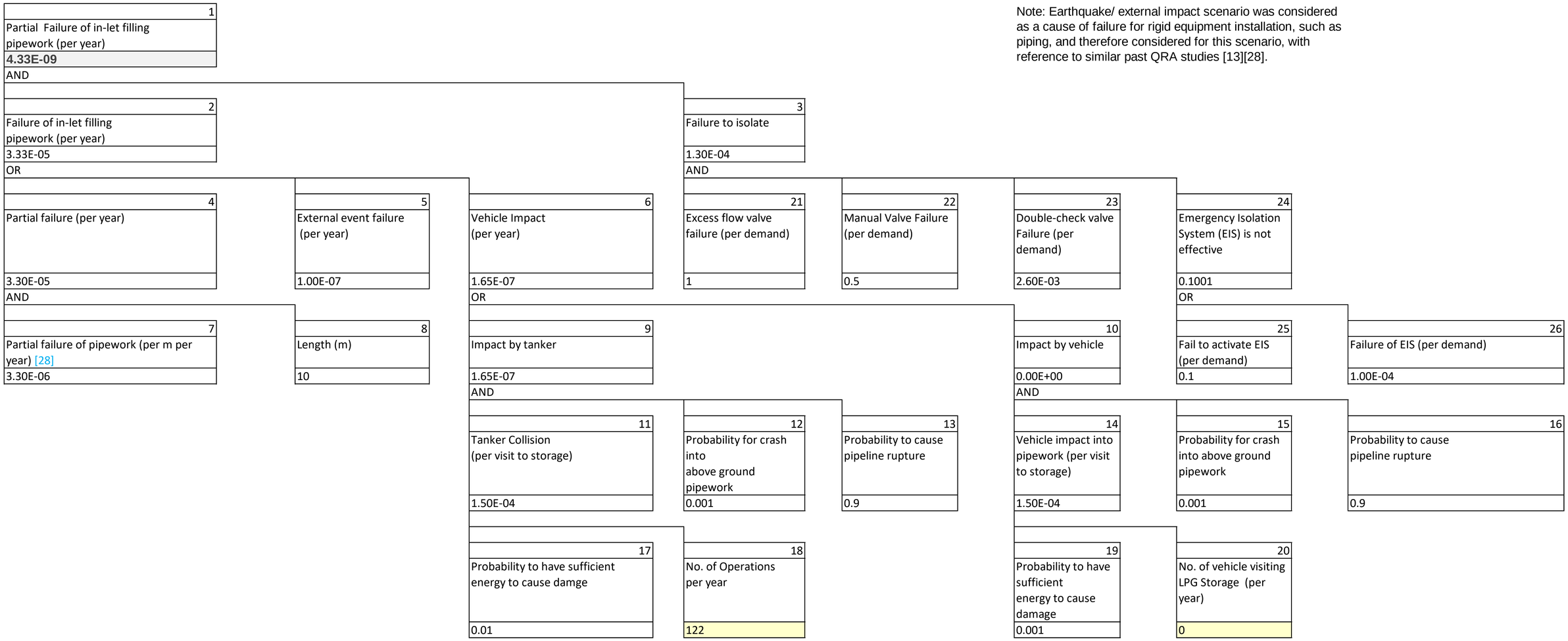
*=(1.5 × no. of tanker delivery)/(24 × 365)

5. Guillotine Failure of in-let filling pipework



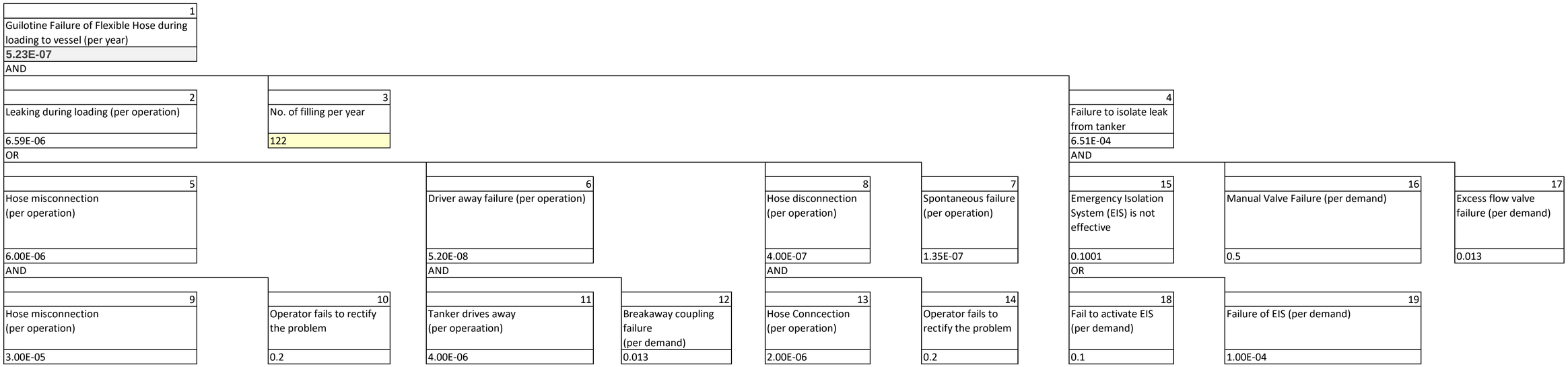
Note: Earthquake/ external impact scenario was considered as a cause of failure for rigid equipment installation, such as piping, and therefore considered for this scenario, with reference to similar past QRA studies [13][28].

6. Partial Failure of in-let filling pipework



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



10. Partial Failure of Flexible Hose during loading to vessel

1
Partial Failure of Flexible Hose during loading to vessel (per year)
3.63E-06

AND

2
Partial Failure (per operation) [28]
5.94E-07

3
No. of filling per year
122

4
Failure to isolate leak from tanker
5.01E-02

AND

5
Emergency Isolation System (EIS) is not effective
0.1001

6
Manual Valve Failure (per demand)
0.5

7
Excess flow valve failure (per demand)
1

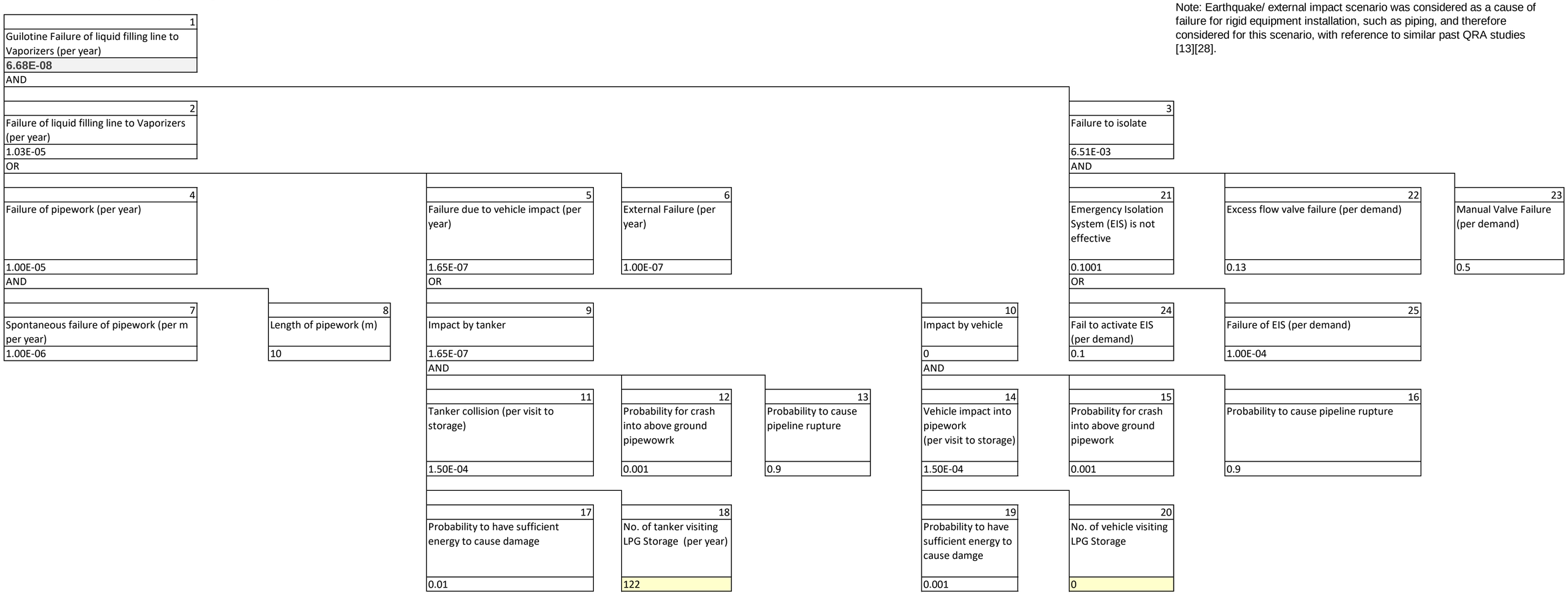
OR

8
Fail to activate EIS (per demand)
0.1

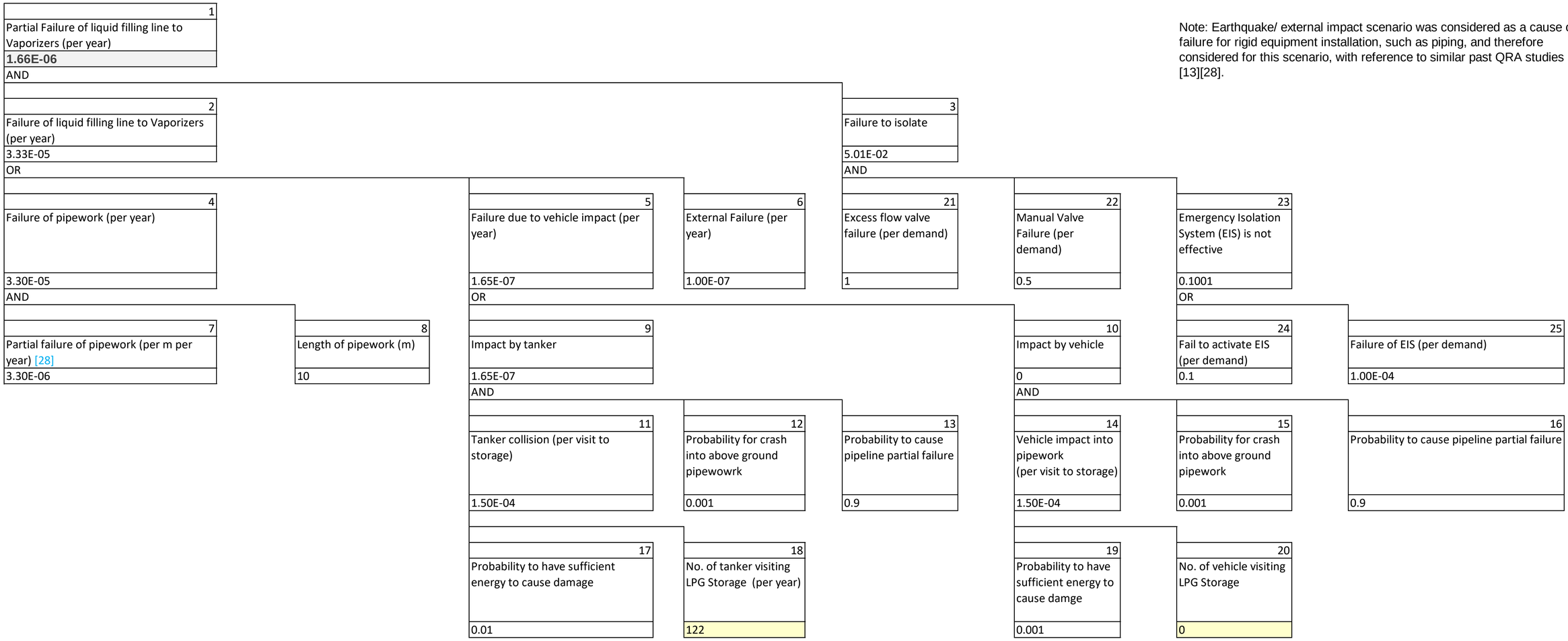
9
Failure of EIS (per demand)
1.00E-04

11. Guilotine Failure of liquid filling line to Vaporizers

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].



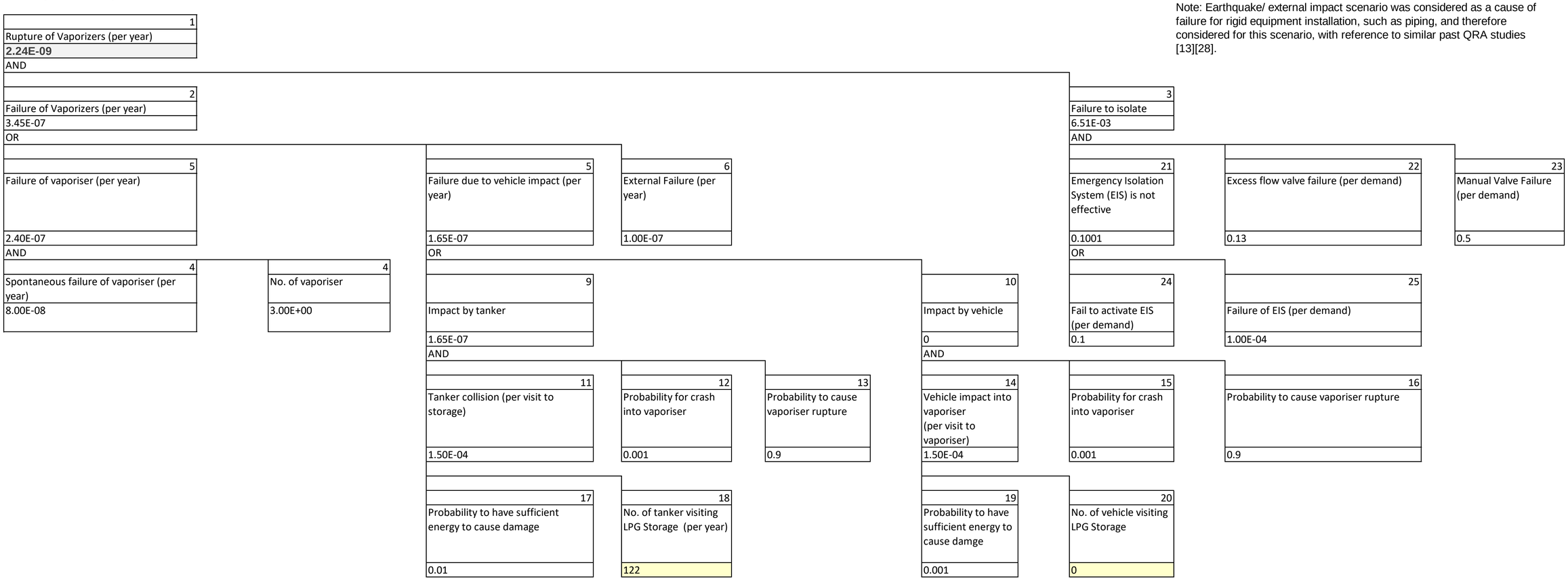
12. Partial Failure of liquid filling line to Vaporizers



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].

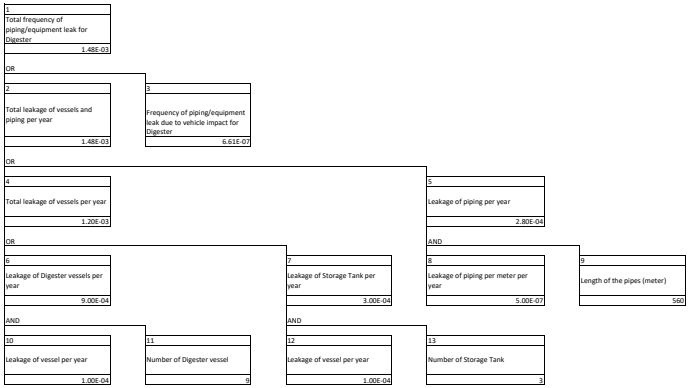
13. Rupture of Vaporizers

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].



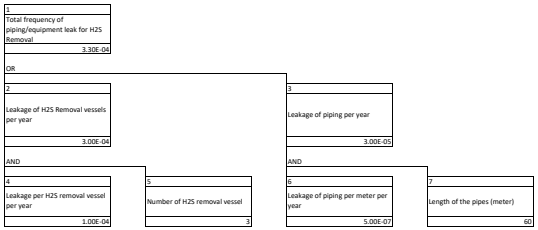
Operation Phase

Leakage of Digester



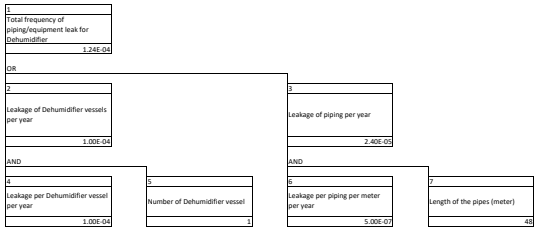
Operation Phase

Leakage of H2S Removal



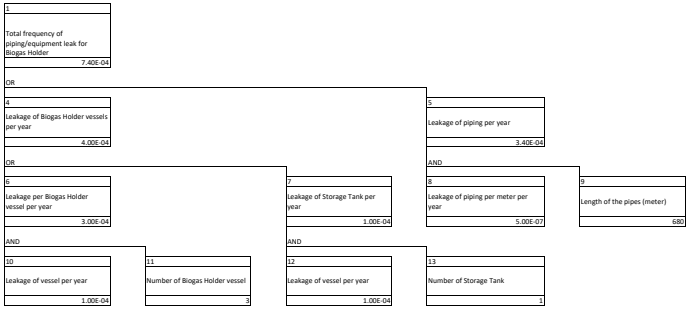
Operation Phase

Leakage of Dehumidifier



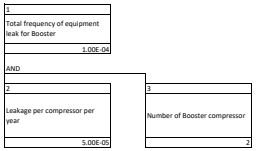
Operation Phase

Leakage of Biogas Holder



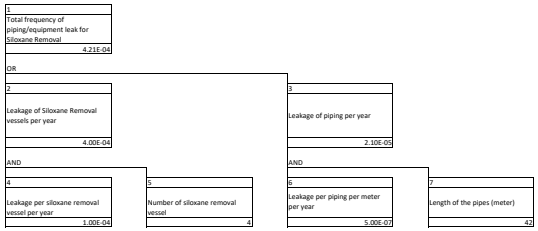
Operation Phase

Leakage of Booster



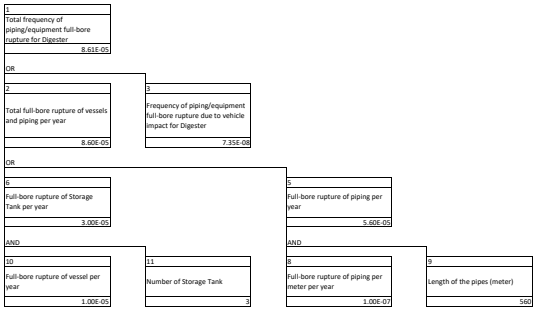
Operation Phase

Leakage of Siloxane Removal



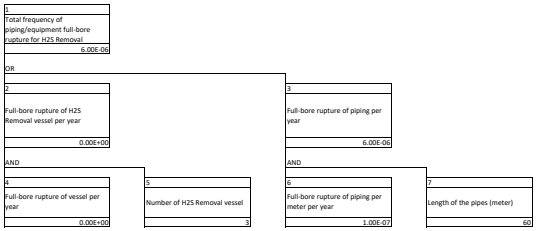
Operation Phase

Rupture of Digester



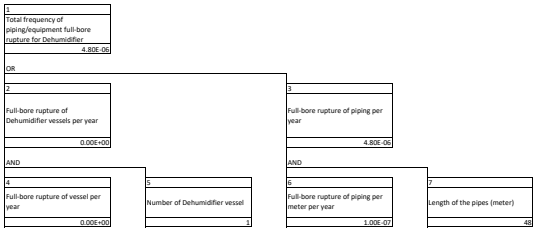
Operation Phase

Rupture of H2S Removal



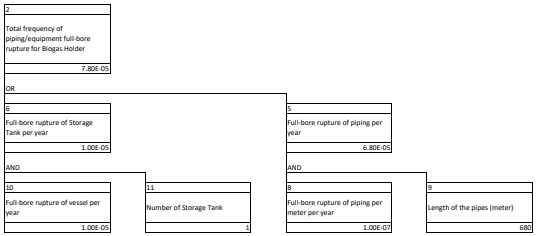
Operation Phase

Rupture of Dehumidifier



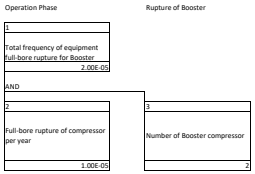
Operation Phase

Rupture of Biogas Holder



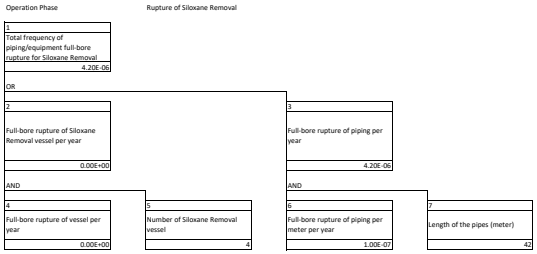
Operation Phase

Rupture of Booster



Operation Phase

Rupture of Siloxane Removal



Operation Phase

Catastrophic Failure of Digester

1
Total frequency of equipment catastrophic failure for Digester
9.00E-05

AND

2
Catastrophic failure of vessel per year
1.00E-05

3
Number of Digester vessel
9

Operation Phase

Catastrophic Failure of H2S Removal

1
Total frequency of equipment catastrophic failure for H2S Removal per year
3.00E-05

AND

2
Catastrophic failure of vessel per year
1.00E-05

3
Number of H2S Removal vessel
3

Operation Phase

Catastrophic Failure of Siloxane Removal

1
Total frequency of equipment catastrophic failure for Siloxane Removal
4.00E-05

AND

2
Catastrophic failure of vessel per year
1.00E-05

3
Number of Siloxane Removal vessel
4

Operation Phase

Catastrophic Failure of Biogas Holder

1
Total frequency of equipment catastrophic failure for Gas Holder
3.04E-05

OR

2
Frequency of equipment catastrophic failure for Gas Holder
3.00E-05

3
Hitting frequency of projectile striking from Lindle
3.80E-07

AND

4
Catastrophic failure of vessel per year
1.00E-05

5
Number of Gas Holder vessel
3

Operation Phase

Catastrophic Failure of Dehumidifier

1
Total frequency of equipment catastrophic failure for Dehumidifier
1.00E-05

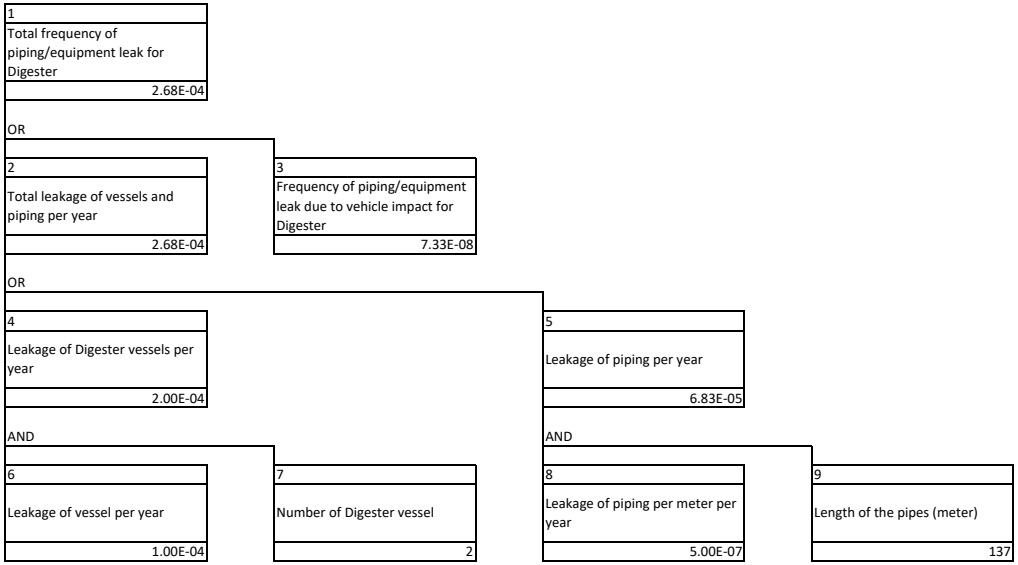
AND

2
Catastrophic failure of vessel per year
1.00E-05

3
Number of Dehumidifier vessel
1

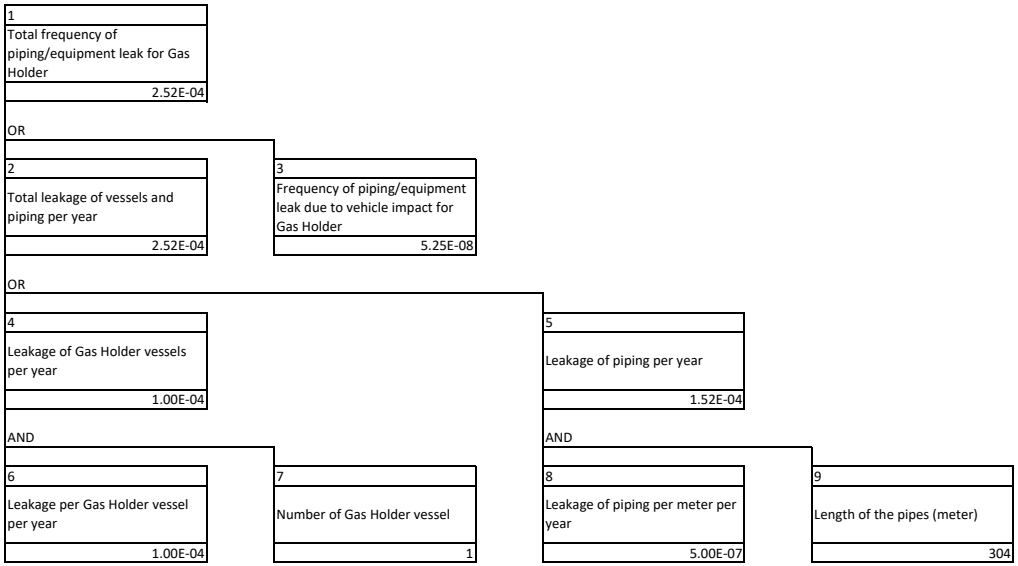
Construction of New West Plant

Leakage of Digester



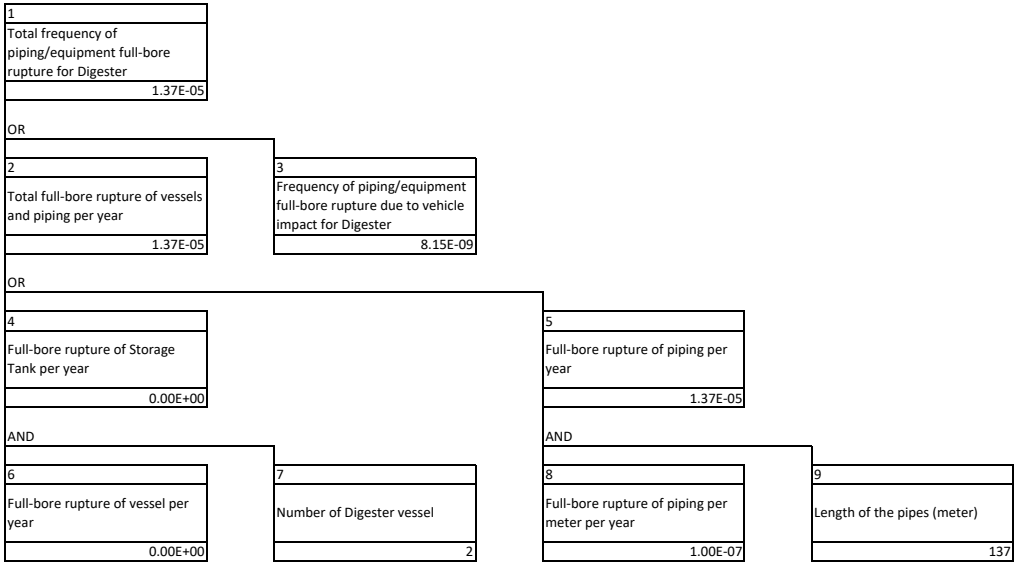
Construction of New West Plant

Leakage of Biogas Holder



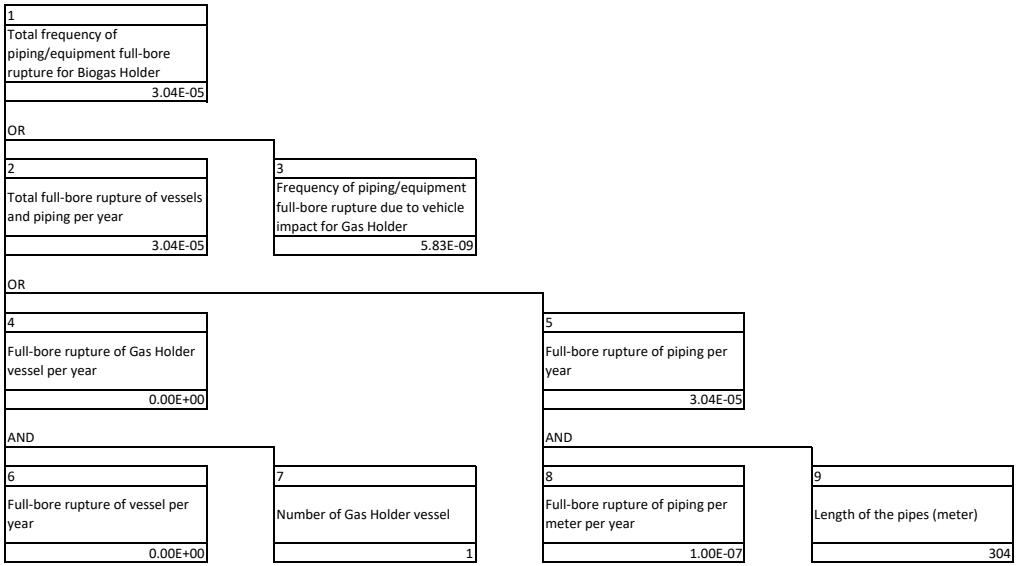
Construction of New West Plant

Rupture of Digester



Construction of New West Plant

Rupture of Biogas Holder



Construction of New West Plant

Catastrophic Failure of Digester

1
Total frequency of equipment catastrophic failure for Digester
2.00E-05

AND

2
Catastrophic failure of vessel per year
1.00E-05

3
Number of Digester vessel
2

Construction of New West Plant

Catastrophic Failure of Biogas Holder

1
Total frequency of equipment catastrophic failure for Gas Holder
1.01E-05

OR

2
Frequency of equipment catastrophic failure for Gas Holder
1.00E-05

3
Hitting frequency of projectile striking from Lindle
9.50E-08

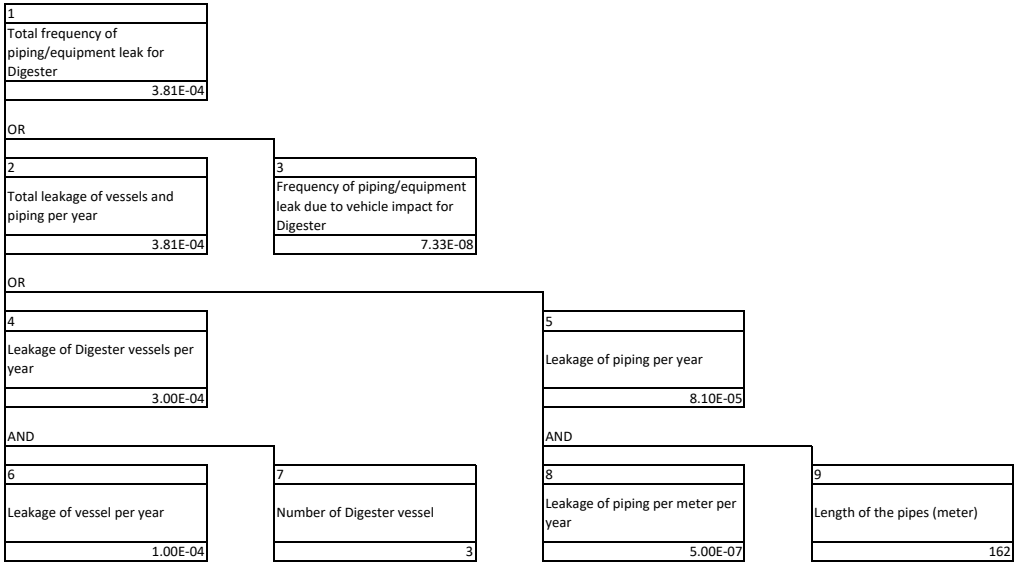
AND

4
Catastrophic failure of vessel per year
1.00E-05

5
Number of Gas Holder vessel
1

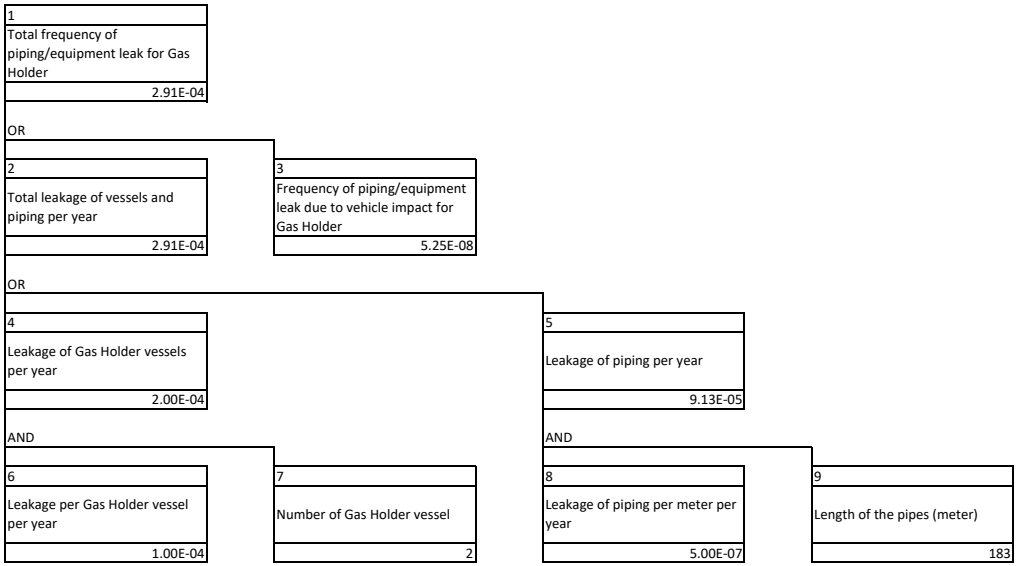
Construction in Existing West Plant

Leakage of Digester



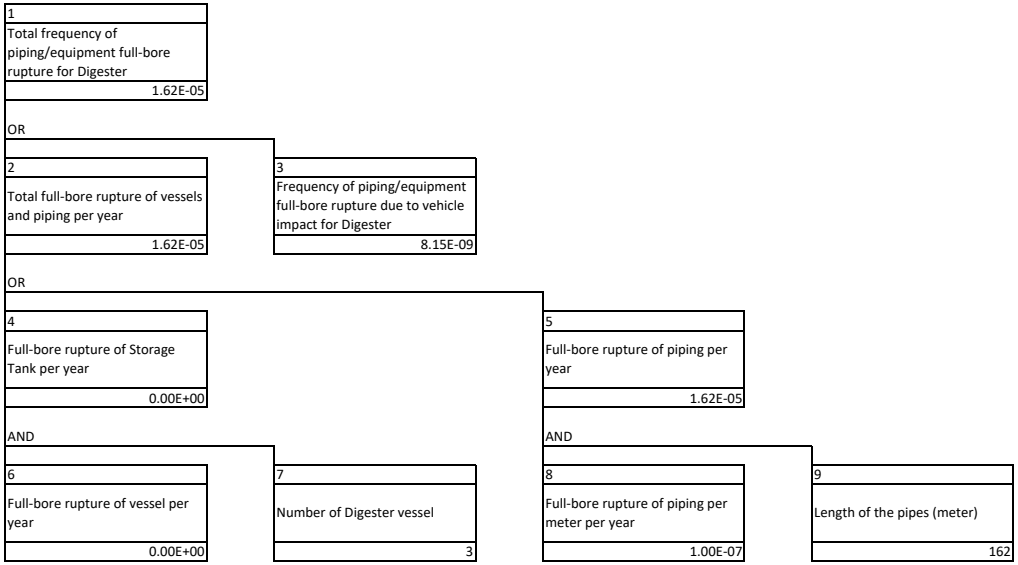
Construction in Existing West Plant

Leakage of Biogas Holder



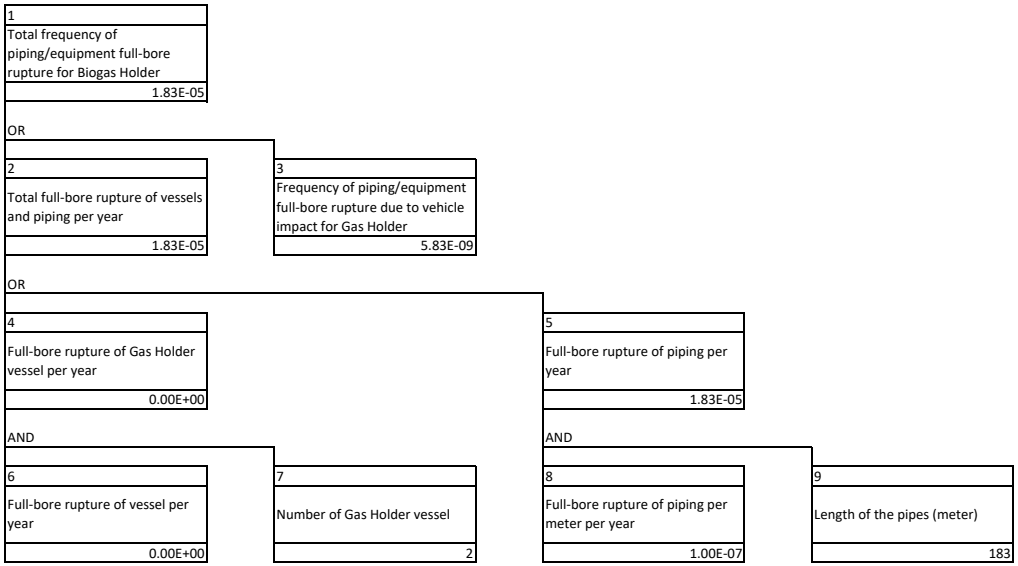
Construction in Existing West Plant

Rupture of Digester



Construction in Existing West Plant

Rupture of Biogas Holder



Construction in Existing West Plant

Catastrophic Failure of Digester

1
Total frequency of equipment catastrophic failure for Digester
3.00E-05

AND

2
Catastrophic failure of vessel per year
1.00E-05

3
Number of Digester vessel
3

Construction in Existing West Plant

Catastrophic Failure of Biogas Holder

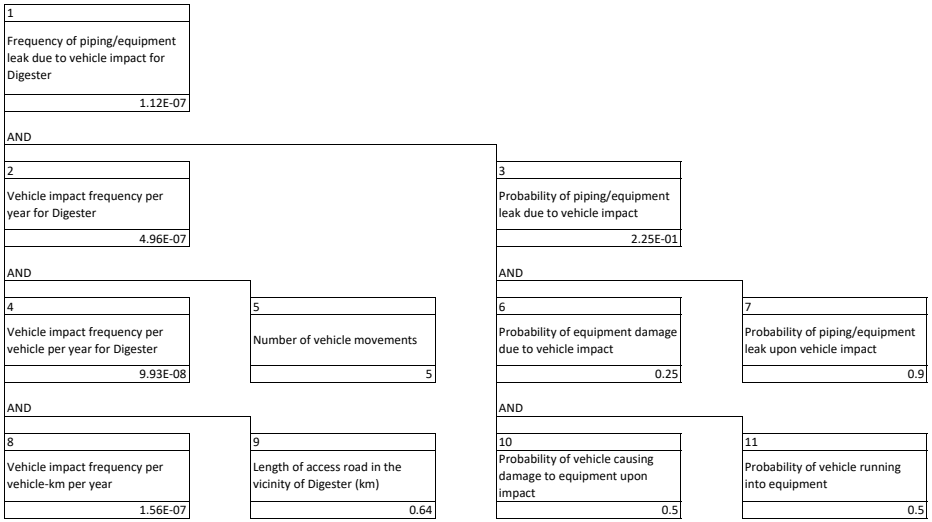
1
Total frequency of equipment catastrophic failure for Gas Holder
2.00E-05

AND

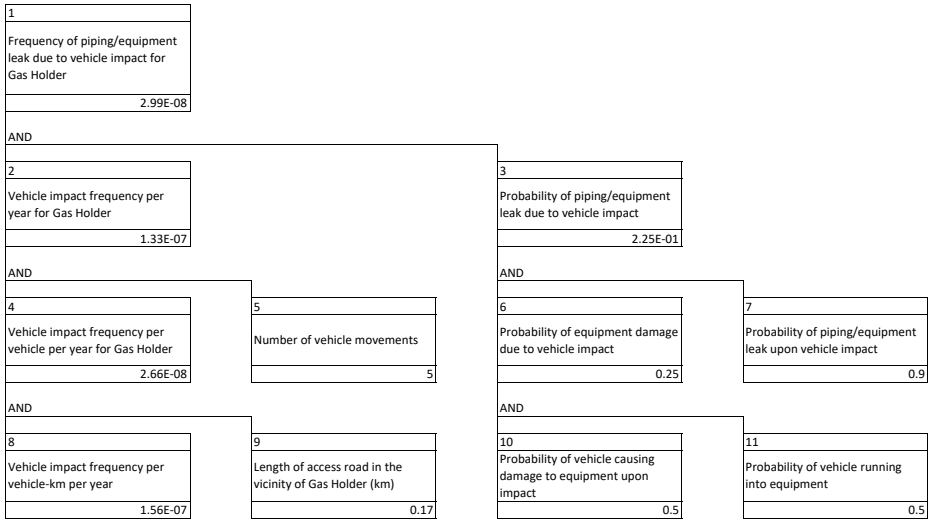
2
Catastrophic failure of vessel per year
1.00E-05

3
Number of Gas Holder vessel
2

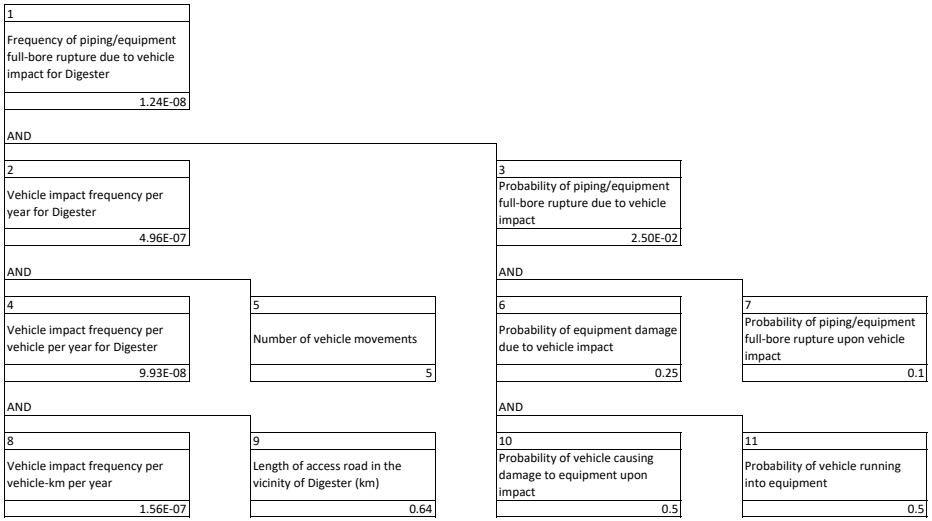
Vehicle Impact | Digester Leakage



Vehicle Impact | Gas Holder Leakage



Vehicle Impact | Digester Rupture



Vehicle Impact | Gas Holder Rupter