# APPENDIX D

## HAZARDS RISK ANALYSIS MODELING ASSUMPTIONS AND RESULTS

Consequence modeling was performed for the following ammonia release and natural gas explosion scenarios:

**Case 1:** The entire contents of one new aqueous ammonia tanks (20,000 gallons) at the VGS site are spilled into a dike area that is five feet high and capable of containing the entire contents of the tank plus 20 percent. The liquid in the dike area then evaporates at a rate estimated from USEPA equations. The storage tank failure was assumed to be caused by an external event or degradation of the equipment. The incremental risk was compared with current facility operations.

**Case 2:** The entire contents of an aqueous ammonia tanker delivery truck are spilled in a vehicle accident at the VGS site. The entire 5,000 gallons of aqueous ammonia spreads in all directions in an unconfined manner to a depth of one centimeter and evaporates. The incremental risk was compared with current facility operations.

**Case 3:** An aqueous ammonia truck is improperly connected/disconnected at VGS and releases 200 gallons of aqueous ammonia before the emergency shut-off can be activated. The spill spreads in an unconfined manner to a depth of one centimeter and evaporates. The risk was estimated compared to a zero baseline.

**Case 4:** The new natural gas connector pipeline for one new CT is ruptured near the main and releases natural gas that forms a cloud and explodes after ten minutes (14,776 pounds of natural gas). The blast impact is estimated.

The purpose of the hazards risk modeling was to estimate the offsite consequences of releases of toxic and flammable materials from equipment installations and modifications at the proposed project sites.

The modeling was based on EPA's RMP Guidance worst-case estimates for toxic releases and explosions. The RMPComp model was used to calculate the size of the impact zones. The EPA endpoint for explosions is the distance from the explosion that is required to reduce the overpressure to one psi. The EPA endpoint for ammonia exposure is the distance from the spill that is required to reduce the concentration to 200 ppm, the ERPG II endpoint for ammonia. The RMPComp program estimates were based on 30 percent aqueous ammonia, which is slightly higher concentration than the 29.5 percent ammonia proposed for this project. The 30 percent concentration is built into RMPComp and was the closest selection available for use.

As of the release of this Final EIR, the aqueous ammonia tanks and the dike areas for the project sites have not yet been designed. However, as a "worst-case" for all ammonia tank release scenarios, the following assumptions were made:

- Ammonia tank dimensions were assumed to be twice as wide as they were high;
- The ammonia tank volume was assumed to be 10 percent larger than the nominal containment volume. (For a tank with 20,000-gallon contents, the tank volume was assumed to be 22,000 gallons);
- All dike areas were assumed to have excess capacity of 20 percent more than the tank contents. (The dike capacity for 20,000-gallon contents was assumed to be 24,000 gallons);
- All dike walls were assumed to be five feet high;
- For unconfined ammonia spills, the liquid was assumed to spread to a thickness of one centimeter in all directions on a flat impervious surface;
- Rural conditions were conservatively assumed to reduce dispersion.

Table D-1 shows the results of the RMPComp model for explosions and spills.

**Table D-1**
**Distance to Endpoint from Center of Upset***

| Case | Event | RMP Comp 200 ppm Endpoint (meters) |
|---|---|---|
| 1 | Aqueous Ammonia Tank Failure to Diked Containment (20,000 gallons) at VGS | 500 |
| 2 | Ammonia Truck Spill Unconfined (5,000 gallons) at VGS | 2,300 |
| 3 | Bad Connect/Disconnect Unconfined (200 gallons) at VGS | 500 |
| 4 | Ruptured Pipeline Natural Gas at VGS (10 Minute Cloud Plus Explosion) | 300 |

**Table D-2**
**Qualitative and Quantitative Estimates of Failures that may Contribute to Hazardous Releases**

| Scenario | Likelihood (Qualitative) | Frequency |
|---|---|---|
| Tank failure from earthquake | Improbable | The frequency of a maximum probable (6.7 Richter) Verdugo earthquake is one per 50 years.[1] Approximately one in ten spherical vessels fail for lateral accelerations >0.2g which can be generated in such an earthquake[2] (bullets/tanks are less vulnerable and would fail less frequently). The expected tank failure rate in an earthquake would be approximate one per 1,000 years. |
| Tank failure (catastrophic) | Improbable | The catastrophic tank failure rate[4] is approximately one per 100 years. Failures are primarily due to cracks. |
| Pipe failure from earthquake | Improbable | The event frequency is approximately once per 100 years but the pipe may not rupture[1]. Assume the pipe failure rate in a maximum probable earthquake is one in ten as for tanks. The number of pipe failures that result in unconfined explosions is estimated to be one in ten (by relating failures and failures plus explosions) for a combined estimate of one per 10,000 years[3,4]. Fires would be of higher probability but less than one per rupture. (The combined fire and pipe failure rate is approximately one per 1,000 years to one per 10,000 years). |
| Pipe failure (catastrophic) | Improbable | The catastrophic pipe failure rate[4] is approximately one per 1,000 years. The number of explosions for pipeline failures is estimated to be an average of one per ten failures (by relating failures with failures plus explosions) for a combined one per 10,000 years[3,4]. |
| Truck accident | Improbable/ Remote | Truck accident rates are approximately one per 8.7-million miles[5]. Assuming a total of 36 truck deliveries of aqueous ammonia per year of an estimated total of 1,300 miles, the expected number of truck accidents will be about one per 6,700 years. The likelihood of release is one in ten and of a major release one in 40[7]. The expected major release frequency is approximately one per 268,000 years. |

**Table D-2**
**Qualitative and Quantitative Estimates of Failures that may Contribute to Hazardous Releases**

| Scenario | Likelihood (Qualitative) | Frequency |
|---|---|---|
| Truck Connect/ Disconnect Accident | Periodic/ Improbable | Human error rate[6] is about one per 2,000 operations. For 36 tankers per year there are 72 connect/disconnects per year. A bad connect/disconnect would be expected about every 28 years. Assume the same release rate as for truck accidents. The likelihood of any connection release (small spill) is one in ten and of a larger (200 gallons) release is one in 40[7]. The approximate larger release rate for connections is about one per 1,100 years. |

Frequent - More than once per year (0 to 1 years)
Periodic - Once per decade (1 to 10 years)
Occasional- During the facility lifetime (10 to 100 years)
Improbable - 100 to 10,000 years
Remote - Not likely to occur at all

1 Magula and Owen, 2000
2 AIChE "Chemical Process Quantitative Risk Analysis"
3 F. Lees, "Loss Prevention in Process Industries," Vol. 1, 1992
4 AIChE "Process Equipment Reliability Data," 1989
5 ENSR 1994 in "Risk of Upset Evaluation, Unocal San Francisco Refinery, Reformulated Gasoline Project
6 T. Kletz, "An Engineers View of Human Error," 1985
7 ENSR 1994
8 USDOT, Federal Railroad Administration, Accident/Incident Bulletin No. 164, CY 1995, Aug. 1996

**10/25/00**

**09:55:38**

***** SCREEN3 MODEL RUN *****

***** VERSION DATED 96043 *****

20,000 gallon spill to a dike with 20% Over Cap (Corrected for open area)

SIMPLE TERRAIN INPUTS:

SOURCE TYPE = AREA

EMISSION RATE (G/(S-M**2)) = 2.87000

SOURCE HEIGHT (M) = .0000

LENGTH OF LARGER SIDE (M) = 5.5200

LENGTH OF SMALLER SIDE (M) = 5.5200

RECEPTOR HEIGHT (M) = .0000

URBAN/RURAL OPTION = RURAL

THE REGULATORY (DEFAULT) MIXING HEIGHT OPTION WAS SELECTED.

THE REGULATORY (DEFAULT) ANEMOMETER HEIGHT OF 10.0 METERS WAS ENTERED.

MODEL ESTIMATES DIRECTION TO MAX CONCENTRATION

BUOY. FLUX = .000 M**4/S**3; MOM. FLUX = .000 M**4/S**2.

*** STABILITY CLASS 6 ONLY ***

*** ANEMOMETER HEIGHT WIND SPEED OF 1.50 M/S ONLY ***

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*** SCREEN AUTOMATED DISTANCES ***

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*** TERRAIN HEIGHT OF 0. M ABOVE STACK BASE USED FOR FOLLOWING DISTANCES ***

| DIST (M) | CONC (UG/M**3) | STAB | U10M (M/S) | USTK (M/S) | MIX HT (M) | PLUME HT (M) | MAX DIR (DEG) |
|---|---|---|---|---|---|---|---|
| 100. | .1823E+07 | 6 | 1.5 | 1.5 | 10000.0 | .00 | 44. |
| 200. | .5743E+06 | 6 | 1.5 | 1.5 | 10000.0 | .00 | 43. |
| 300. | .2906E+06 | 6 | 1.5 | 1.5 | 10000.0 | .00 | 37. |
| 400. | .1787E+06 | 6 | 1.5 | 1.5 | 10000.0 | .00 | 31. |
| 500. | .1225E+06 | 6 | 1.5 | 1.5 | 10000.0 | .00 | 37. |
| 600. | .8987E+05 | 6 | 1.5 | 1.5 | 10000.0 | .00 | 32. |
| 700. | .6920E+05 | 6 | 1.5 | 1.5 | 10000.0 | .00 | 37. |
| 800. | .5591E+05 | 6 | 1.5 | 1.5 | 10000.0 | .00 | 32. |
| 900. | .4633E+05 | 6 | 1.5 | 1.5 | 10000.0 | .00 | 32. |

1000. .3916E+05 6 1.5 1.5 10000.0 .00 44.

MAXIMUM 1-HR CONCENTRATION AT OR BEYOND 100. M:

100. .1823E+07 6 1.5 1.5 10000.0 .00 44.

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*** SCREEN DISCRETE DISTANCES ***

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*** TERRAIN HEIGHT OF 0. M ABOVE STACK BASE USED FOR FOLLOWING DISTANCES ***

| DIST (M) | CONC (UG/M**3) | STAB | U10M (M/S) | USTK (M/S) | MIX HT (M) | PLUME HT (M) | MAX DIR (DEG) |
|---|---|---|---|---|---|---|---|
| 400. | .1787E+06 | 6 | 1.5 | 1.5 | 10000.0 | .00 | 31. |
| 450. | .1464E+06 | 6 | 1.5 | 1.5 | 10000.0 | .00 | 31. |
| 460. | .1411E+06 | 6 | 1.5 | 1.5 | 10000.0 | .00 | 31. |
| 470. | .1360E+06 | 6 | 1.5 | 1.5 | 10000.0 | .00 | 41. |
| 465. | .1385E+06 | 6 | 1.5 | 1.5 | 10000.0 | .00 | 39. |
| 463. | .1395E+06 | 6 | 1.5 | 1.5 | 10000.0 | .00 | 39. |
| 462. | .1400E+06 | 6 | 1.5 | 1.5 | 10000.0 | .00 | 31. |

700. .6920E+05 6 1.5 1.5 10000.0 .00 37.

650. .7846E+05 6 1.5 1.5 10000.0 .00 32.

660. .7645E+05 6 1.5 1.5 10000.0 .00 37.

670. .7453E+05 6 1.5 1.5 10000.0 .00 37.

680. .7268E+05 6 1.5 1.5 10000.0 .00 43.

690. .7090E+05 6 1.5 1.5 10000.0 .00 44.

691. .7072E+05 6 1.5 1.5 10000.0 .00 32.

692. .7055E+05 6 1.5 1.5 10000.0 .00 44.

693. .7038E+05 6 1.5 1.5 10000.0 .00 44.

694. .7021E+05 6 1.5 1.5 10000.0 .00 32.

695. .7004E+05 6 1.5 1.5 10000.0 .00 44.

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*** SUMMARY OF SCREEN MODEL RESULTS ***

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| CALCULATION PROCEDURE | MAX CONC (UG/M**3) | DIST TO MAX (M) | TERRAIN HT (M) |
|---|---|---|---|
| SIMPLE TERRAIN | .1823E+07 | 100. | 0. |

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** REMEMBER TO INCLUDE BACKGROUND CONCENTRATIONS **

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**10/31/00**

**11:30:27**

***** SCREEN3 MODEL RUN *****

***** VERSION DATED 96043 *****

Unconfined 5000 Gallon Spill Corrected for 15.4 Minute Duration

SIMPLE TERRAIN INPUTS:

SOURCE TYPE = AREA

EMISSION RATE (G/(S-M**2)) = .735000

SOURCE HEIGHT (M) = .0000

LENGTH OF LARGER SIDE (M) = 43.5000

LENGTH OF SMALLER SIDE (M) = 43.5000

RECEPTOR HEIGHT (M) = .0000

URBAN/RURAL OPTION = RURAL

THE REGULATORY (DEFAULT) MIXING HEIGHT OPTION WAS SELECTED.

THE REGULATORY (DEFAULT) ANEMOMETER HEIGHT OF 10.0 METERS WAS ENTERED.

MODEL ESTIMATES DIRECTION TO MAX CONCENTRATION

BUOY. FLUX = .000 M**4/S**3; MOM. FLUX = .000 M**4/S**2.

*** STABILITY CLASS 6 ONLY ***

*** ANEMOMETER HEIGHT WIND SPEED OF 1.50 M/S ONLY ***

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*** SCREEN AUTOMATED DISTANCES ***

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*** TERRAIN HEIGHT OF 0. M ABOVE STACK BASE USED FOR FOLLOWING DISTANCES ***

| DIST (M) | CONC (UG/M**3) | STAB | U10M (M/S) | USTK (M/S) | MIX HT (M) | PLUME HT (M) | MAX DIR (DEG) |
|---|---|---|---|---|---|---|---|
| 100. | .9509E+07 | 6 | 1.5 | 1.5 | 10000.0 | .00 | 45. |
| 200. | .4736E+07 | 6 | 1.5 | 1.5 | 10000.0 | .00 | 45. |
| 300. | .3042E+07 | 6 | 1.5 | 1.5 | 10000.0 | .00 | 45. |
| 400. | .2141E+07 | 6 | 1.5 | 1.5 | 10000.0 | .00 | 44. |
| 500. | .1590E+07 | 6 | 1.5 | 1.5 | 10000.0 | .00 | 45. |
| 600. | .1229E+07 | 6 | 1.5 | 1.5 | 10000.0 | .00 | 44. |
| 700. | .9795E+06 | 6 | 1.5 | 1.5 | 10000.0 | .00 | 45. |
| 800. | .8098E+06 | 6 | 1.5 | 1.5 | 10000.0 | .00 | 44. |
| 900. | .6827E+06 | 6 | 1.5 | 1.5 | 10000.0 | .00 | 43. |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1000. | .5848E+06 | 6 | 1.5 | 1.5 | 10000.0 | .00 | 39. |
| 1100. | .5095E+06 | 6 | 1.5 | 1.5 | 10000.0 | .00 | 45. |
| 1200. | .4490E+06 | 6 | 1.5 | 1.5 | 10000.0 | .00 | 45. |
| 1300. | .3994E+06 | 6 | 1.5 | 1.5 | 10000.0 | .00 | 36. |
| 1400. | .3580E+06 | 6 | 1.5 | 1.5 | 10000.0 | .00 | 41. |
| 1500. | .3232E+06 | 6 | 1.5 | 1.5 | 10000.0 | .00 | 43. |
| 1600. | .2936E+06 | 6 | 1.5 | 1.5 | 10000.0 | .00 | 31. |
| 1700. | .2682E+06 | 6 | 1.5 | 1.5 | 10000.0 | .00 | 31. |
| 1800. | .2462E+06 | 6 | 1.5 | 1.5 | 10000.0 | .00 | 45. |
| 1900. | .2270E+06 | 6 | 1.5 | 1.5 | 10000.0 | .00 | 43. |
| 2000. | .2102E+06 | 6 | 1.5 | 1.5 | 10000.0 | .00 | 45. |
| 2100. | .1961E+06 | 6 | 1.5 | 1.5 | 10000.0 | .00 | 40. |
| 2200. | .1835E+06 | 6 | 1.5 | 1.5 | 10000.0 | .00 | 38. |
| 2300. | .1723E+06 | 6 | 1.5 | 1.5 | 10000.0 | .00 | 36. |
| 2400. | .1621E+06 | 6 | 1.5 | 1.5 | 10000.0 | .00 | 33. |
| 2500. | .1529E+06 | 6 | 1.5 | 1.5 | 10000.0 | .00 | 32. |
| 2600. | .1446E+06 | 6 | 1.5 | 1.5 | 10000.0 | .00 | 31. |
| 2700. | .1370E+06 | 6 | 1.5 | 1.5 | 10000.0 | .00 | 32. |
| 2800. | .1301E+06 | 6 | 1.5 | 1.5 | 10000.0 | .00 | 36. |
| 2900. | .1237E+06 | 6 | 1.5 | 1.5 | 10000.0 | .00 | 37. |
| 3000. | .1179E+06 | 6 | 1.5 | 1.5 | 10000.0 | .00 | 41. |
| 3500. | .9565E+05 | 6 | 1.5 | 1.5 | 10000.0 | .00 | 32. |

4000. .7981E+05 6 1.5 1.5 10000.0 .00 31.

4500. .6804E+05 6 1.5 1.5 10000.0 .00 40.

MAXIMUM 1-HR CONCENTRATION AT OR BEYOND 100. M:

100. .9509E+07 6 1.5 1.5 10000.0 .00 45.

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*** SCREEN DISCRETE DISTANCES ***

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*** TERRAIN HEIGHT OF 0. M ABOVE STACK BASE USED FOR FOLLOWING DISTANCES ***

| DIST (M) | CONC (UG/M**3) | STAB | U10M (M/S) | USTK (M/S) | MIX HT (M) | PLUME HT (M) | MAX DIR (DEG) |
|---|---|---|---|---|---|---|---|
| 2600. | .1446E+06 | 6 | 1.5 | 1.5 | 10000.0 | .00 | 31. |
| 2610. | .1438E+06 | 6 | 1.5 | 1.5 | 10000.0 | .00 | 32. |
| 2620. | .1430E+06 | 6 | 1.5 | 1.5 | 10000.0 | .00 | 32. |
| 2630. | .1423E+06 | 6 | 1.5 | 1.5 | 10000.0 | .00 | 32. |
| 2640. | .1415E+06 | 6 | 1.5 | 1.5 | 10000.0 | .00 | 32. |
| 2650. | .1407E+06 | 6 | 1.5 | 1.5 | 10000.0 | .00 | 32. |

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 2660.  .1400E+06   6    1.5    1.5 10000.0    .00    32.

 4400.  .7014E+05   6    1.5    1.5 10000.0    .00    32.

 4410.  .6993E+05   6    1.5    1.5 10000.0    .00    35.


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    *** SUMMARY OF SCREEN MODEL RESULTS ***

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 CALCULATION       MAX CONC    DIST TO   TERRAIN

 PROCEDURE        (UG/M**3)    MAX (M)    HT (M)

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SIMPLE TERRAIN     .9509E+07     100.       0.


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** REMEMBER TO INCLUDE BACKGROUND CONCENTRATIONS **

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**10/31/00**

**11:48:43**

***** SCREEN3 MODEL RUN *****

***** VERSION DATED 96043 *****

Unconfined Spill of 200 Gallons Corrected for 15.4 Minutes Duration

SIMPLE TERRAIN INPUTS:

SOURCE TYPE = AREA

EMISSION RATE (G/(S-M**2)) = .735000

SOURCE HEIGHT (M) = .0000

LENGTH OF LARGER SIDE (M) = 8.7000

LENGTH OF SMALLER SIDE (M) = 8.7000

RECEPTOR HEIGHT (M) = .0000

URBAN/RURAL OPTION = RURAL

THE REGULATORY (DEFAULT) MIXING HEIGHT OPTION WAS SELECTED.

THE REGULATORY (DEFAULT) ANEMOMETER HEIGHT OF 10.0 METERS WAS ENTERED.

MODEL ESTIMATES DIRECTION TO MAX CONCENTRATION

BUOY. FLUX = .000 M**4/S**3; MOM. FLUX = .000 M**4/S**2.

*** STABILITY CLASS 6 ONLY ***

*** ANEMOMETER HEIGHT WIND SPEED OF 1.50 M/S ONLY ***

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*** SCREEN AUTOMATED DISTANCES ***

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*** TERRAIN HEIGHT OF 0. M ABOVE STACK BASE USED FOR FOLLOWING DISTANCES ***

| DIST (M) | CONC (UG/M**3) | STAB | U10M (M/S) | USTK (M/S) | MIX HT (M) | PLUME HT (M) | MAX DIR (DEG) |
|---|---|---|---|---|---|---|---|
| 100. | .1056E+07 | 6 | 1.5 | 1.5 | 10000.0 | .00 | 45. |
| 200. | .3548E+06 | 6 | 1.5 | 1.5 | 10000.0 | .00 | 45. |
| 300. | .1822E+06 | 6 | 1.5 | 1.5 | 10000.0 | .00 | 31. |
| 400. | .1127E+06 | 6 | 1.5 | 1.5 | 10000.0 | .00 | 35. |
| 500. | .7747E+05 | 6 | 1.5 | 1.5 | 10000.0 | .00 | 40. |
| 600. | .5696E+05 | 6 | 1.5 | 1.5 | 10000.0 | .00 | 31. |

MAXIMUM 1-HR CONCENTRATION AT OR BEYOND 100. M:

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 100. | .1056E+07 | 6 | 1.5 | 1.5 | 10000.0 | .00 | 45. |

**********

*** SCREEN DISCRETE DISTANCES ***

**********

*** TERRAIN HEIGHT OF 0. M ABOVE STACK BASE USED FOR FOLLOWING DISTANCES ***

| DIST (M) | CONC (UG/M**3) | U10M STAB | USTK (M/S) | MIX HT (M/S) | PLUME (M) | MAX HT (M) | DIR (DEG) |
|---|---|---|---|---|---|---|---|
| 350. | .1410E+06 | 6 | 1.5 | 1.5 | 10000.0 | .00 | 44. |
| 351. | .1403E+06 | 6 | 1.5 | 1.5 | 10000.0 | .00 | 41. |
| 352. | .1396E+06 | 6 | 1.5 | 1.5 | 10000.0 | .00 | 41. |
| 530. | .7022E+05 | 6 | 1.5 | 1.5 | 10000.0 | .00 | 45. |
| 531. | .7000E+05 | 6 | 1.5 | 1.5 | 10000.0 | .00 | 45. |
| 532. | .6978E+05 | 6 | 1.5 | 1.5 | 10000.0 | .00 | 45. |

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*** SUMMARY OF SCREEN MODEL RESULTS ***

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| CALCULATION PROCEDURE | MAX CONC (UG/M**3) | DIST TO MAX (M) | TERRAIN HT (M) |
|---|---|---|---|
| SIMPLE TERRAIN | .1056E+07 | 100. | 0. |

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** REMEMBER TO INCLUDE BACKGROUND CONCENTRATIONS **

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**RMP*Comp Ver. 1.06**

**Results of Consequence Analysis**

Chemical: Methane

CAS #: 74-82-8

Category: Flammable Gas

Scenario: Worst-case

Quantity Released: 14776 pounds

Release Type: Vapor Cloud Explosion

Estimated Distance to 1 psi overpressure: .2 miles (.3 kilometers)

--------Assumptions About This Scenario---------

Wind Speed: 1.5 meters/second (3.4 miles/hour)

Stability Class: F

Air Temperature: 77 degrees F (25 degrees C)

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**RMP*Comp Ver. 1.06**

**Results of Consequence Analysis**

Chemical: Ammonia (water solution)  30%

CAS #: 7664-41-7

Category: Toxic Liquid

Scenario: Worst-case

Quantity Released: 20000 gallons

Liquid Temperature: 77 F

Mitigation Measures:

Diked area: 642 square feet

Dike height: 5 feet

Release Rate to Outside Air: 23.4 pounds per minute

Topography: Rural surroundings (terrain generally flat and unobstructed)

Toxic Endpoint: 0.14 mg/L; basis: ERPG-2

Estimated Distance to Toxic Endpoint: 0.3 miles (0.5 kilometers)

--------Assumptions About This Scenario---------

Wind Speed: 1.5 meters/second (3.4 miles/hour)

Stability Class: F

Air Temperature: 77 degrees F (25 degrees C)

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**RMP*Comp Ver. 1.06**

**Results of Consequence Analysis**

Chemical: Ammonia (water solution)  30%

CAS #: 7664-41-7

Category: Toxic Liquid

Scenario: Worst-case

Quantity Released: 5000 gallons

Liquid Temperature: 77 F

Mitigation Measures: NONE

Release Rate to Outside Air: 737 pounds per minute

Topography: Rural surroundings (terrain generally flat and unobstructed)

Toxic Endpoint: 0.14 mg/L; basis: ERPG-2

Estimated Distance to Toxic Endpoint: 1.4 miles (2.3 kilometers)

--------Assumptions About This Scenario---------

Wind Speed: 1.5 meters/second (3.4 miles/hour)

Stability Class: F

Air Temperature: 77 degrees F (25 degrees C)

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**RMP*Comp Ver. 1.06**

**Results of Consequence Analysis**

Chemical: Ammonia (water solution)  30%

CAS #: 7664-41-7

Category: Toxic Liquid

Scenario: Worst-case

Quantity Released: 200 gallons

Liquid Temperature: 77 F

Mitigation Measures: NONE

Release Rate to Outside Air: 29.5 pounds per minute

Topography: Rural surroundings (terrain generally flat and unobstructed)

Toxic Endpoint: 0.14 mg/L; basis: ERPG-2

Estimated Distance to Toxic Endpoint: 0.3 miles (0.5 kilometers)

--------Assumptions About This Scenario---------

Wind Speed: 1.5 meters/second (3.4 miles/hour)

Stability Class: F

Air Temperature: 77 degrees F (25 degrees C)

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**DWP Calculations (10/24/00), Toxic Spill and Pipeline Explosion**

**DWP Calculations (10/24/00), Toxic Spill, Pipeline Explosion**

| Input | Chemical | Hc (joules/kg) | Hv (joules/kg) | Cp (joules/kg-K) | Tb (K) |
|---|---|---|---|---|---|
| 1 | Diesel | 4.81E+07 | 275218 | 1609 | 447.0 |
| 2 | Ethanol | 2.97E+07 | 866265 | 2407 | 351.4 |
| 3 | Gasoline | 4.78E+07 | 300513 | 1626 | 398.7 |
| 4 | Pentane | 4.86E+07 | 356415 | 1629 | 309.0 |
| 5 | MTBE | 3.87E+07 | 320237 | 2098 | 327.0 |
| 6 | n-Nonane | 4.77E+07 | 287192 | 1611 | 423.5 |
| 7 | Nonenes | 4.71E+07 | 287285 | 1565 | 419.8 |
| 8 | Butane | 4.90E+07 | 384400 | | |
| 9 | Hydrogen | 1.30E+08 | 450189 | | |
| 10 | Propylene | 4.88E+07 | 436497 | | |
| 11 | Methane | 5.54E+07 | 508713 | | |

1,3,4,6,8,11 Petroleum Refining, J. Gary and G Handwerk, Marcel Dekker, Inc, 1975
2,10 Perry's Chemical Engineering Handbook
5 Conversation with Dennis Feist, Equilon/Shell
7 ARCO Table 1C1.3
9 Standard Handbook for ME, Marks

| Confined Spill | Input | *Chemical* | Gallons | Cu ft + 20% | Area (sq ft) | Area (sq m) | Square L (ft) | Square L (m) |
|---|---|---|---|---|---|---|---|---|
| ***Tank Vol*** | | Aqueous NH3 | 30,000 | 4812.8 | 962.6 | 89.5 | | 9.5 |
| | | | | | | | 31.0 | |
| ***Pool Depth (ft)*** | 5 | | | | | | | |

| Confined Spill | Input | *Chemical* | Gallons | Cu ft + 20% | Area (sq ft) | Area (sq m) | L (ft) | L (m) |
|---|---|---|---|---|---|---|---|---|
| ***Tank Vol*** | | Aqueous NH3 | 20,000 | 3208.6 | 641.7 | 59.6 | 25.3 | 7.7 |
| ***Pool Depth (ft)*** | 5 | | | | | | | |

| Chemical | Gallons | *lbs/gal* | Pounds | kg | Lbs NH3 |
|---|---|---|---|---|---|
| Aqueous NH3 | 20000 | 7.37 | 1.47E+05 | 6.70E+04 | 4.42E+04 |
| Aqueous NH3 | 30000 | 7.37 | 2.21E+05 | 1.01E+05 | 6.63E+04 |
| Aqueous NH3 | 5000 | 7.37 | 3.69E+04 | 1.68E+04 | 1.11E+04 |
| Aqueous NH3 | 200 | 7.37 | 1.47E+03 | 6.70E+02 | 4.42E+02 |

**DWP Calculations (10/24/00), Toxic Spill, Pipeline Explosion**

| Input | Chemical | Hc (joules/kg) | Hv (joules/kg) | Cp (joules/kg-K) | Tb (K) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Aqueous NH3 | 28 | 7.37 | 2.06E+02 | 9.38E+01 | 6.19E+01 | | | | | |
| | Aqueous NH3 | 0 | 7.37 | 0.00E+00 | 0.00E+00 | 0.00E+00 | | | | | |
| **Unconfined Spills 1 cm depth (0.39 inches or 0.0328 feet)** | | | | | | **Circle** | **Circle** | **Square** | | | |
| | | **Gallons** | **Cu ft** | **Area (sq ft)** | **Area (sq m)** | **D (ft)** | **D (m)** | **L (m)** | | | |
| | Tank Truck | 5000 | 668.4 | 20379.5 | 1889.6 | 161.1 | 49.1 | 43.47 | | | |
| | Disconnect | 200 | 26.7 | 815.2 | 75.6 | 32.2 | 9.8 | 8.69 | | | |
| | Pipeline Rupture | 28 | 3.7 | 114.1 | 10.6 | 12.1 | 3.7 | 3.25 | | | |
| *****Dike Area=** | 20000 | 642 | sq ft | 59.67 | sq m | | | | | | |
| | **EPA 10 Minute Average for 30% Ammonia** | | | | | | | | | | |
| | | | **1.5 m/s** | **3.0 m/s** | | | **1.5 m/3** | **3.0 m/s** | | | **Dike** |
| **Temp** | **29.5% in mm** | **EPA in mm** | **Qr (lbs/min)** | **Qr (lbs/min)** | **Temp** | **T (C)** | **gm/s/m**2** | **gm/s/m**2** | **T (C)** | | **gm/sec** |
| 77.00 | 703.44 | 332.00 | 22.67 | NA | 77.00 | 25.00 | 2.87 | NA | 25.00 | | 171.41 |
| 77.00 | 703.44 | 248.00 | NA | 29.17 | 77.00 | 25.00 | NA | 3.70 | 25.00 | | 220.54 |
| | | **Time (min)** | 1950.31 | | | | | | | | |
| *****Dike Area=** | 30000 | 962.6 | sq ft | 89.46 | sq m | | | | | | |
| | **EPA 10 Minute Average for 30% Ammonia** | | | | | | | | | | |
| | | | **1.5 m/s** | **3.0 m/s** | | | **1.5 m/3** | **3.0 m/s** | | | **Dike** |
| **Temp** | **29.5% in mm** | **EPA in mm** | **Qr (lbs/min)** | **Qr (lbs/min)** | **Temp** | **T (C)** | **gm/s/m**2** | **gm/s/m**2** | **T (C)** | | **gm/sec** |
| 77.00 | 703.44 | 332.00 | 34.00 | NA | 77.00 | 25.00 | 2.87 | NA | 25.00 | | 257.01 |
| 77.00 | 703.44 | 248.00 | NA | 43.74 | 77.00 | 25.00 | NA | 3.70 | 25.00 | | 330.67 |
| | | **Time (min)** | 1951.12 | | | | | | | | |
| **Truck Area** | 5000 | 20380 | sq ft | 1894.05 | sq m | | | | | | |
| | **EPA 10 Minute Average for 30% Ammonia** | | | | | | | | | | |

**DWP Calculations (10/24/00), Toxic Spill, Pipeline Explosion**

| Input | Chemical | Hc (joules/kg) | Hv (joules/kg) | Cp (joules/kg-K) | Tb (K) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1.5 m/s | 3.0 m/s | | | 1.5 m/3 | 3.0 m/s | | Pool |
| Temp | 29.5% in mm | EPA in mm | Qr (lbs/min) | Qr (lbs/min) | Temp | T (C) | gm/s/m**2 | gm/s/m**2 | T (C) | gm/sec |
| 77 | 703.44 | 332.00 | 719.76 | NA | 77.00 | 25.00 | 2.87 | NA | 25.00 | 5441.35 |
| 77 | 703.44 | 248.00 | NA | 926.05 | 77.00 | 25.00 | NA | 3.70 | 25.00 | 7000.90 |
| | | Time (min) | 15.36 | | | | | | | |
| Leak Area | 200 | 815.2 | sq ft | 75.76 | sq m | | | | | |
| | | EPA 10 Minute Average for 30% Ammonia | | | | | | | | |
| | | | 1.5 m/s | 3.0 m/s | | | 1.5 m/3 | 3.0 m/s | | Puddle |
| Temp | 29.5% in mm | EPA in mm | Qr (lbs/min) | Qr (lbs/min) | Temp | T (C) | gm/s/m**2 | gm/s/m**2 | T (C) | gm/sec |
| 77 | 703.44 | 332.00 | 28.79 | NA | 77.00 | 25.00 | 2.87 | NA | 25.00 | 217.65 |
| 77 | 703.44 | 248.00 | NA | 37.04 | 77.00 | 25.00 | NA | 3.70 | 25.00 | 280.04 |
| | | Time (min) | 15.36 | | | | | | | |
| Pipeline Leak | 28 | 114.1 | sq ft | 10.60 | sq m | | | | | |
| | | EPA 10 Minute Average for 30% Ammonia | | | | | | | | |
| | | | 1.5 m/s | 3.0 m/s | | | 1.5 m/3 | 3.0 m/s | | Puddle |
| Temp | 29.5% in mm | EPA in mm | Qr (lbs/min) | Qr (lbs/min) | Temp | T (C) | gm/s/m**2 | gm/s/m**2 | T (C) | gm/sec |
| 77 | 703.44 | 332.00 | 4.03 | NA | 77.00 | 25.00 | 2.87 | NA | 25.00 | 30.46 |
| 77 | 703.44 | 248.00 | NA | 5.18 | 77.00 | 25.00 | NA | 3.70 | 25.00 | 39.20 |
| | | Time (min) | 15.36 | | | | | | | |

| Blast distance to 1 psi | | Wt Pounds | Chemical | Wt (kg) | Hc (joules/kg) | x (m) |
|---|---|---|---|---|---|---|
| | HGS | 73879 | Methane | 3.36E+04 | 5.54E+07 | 580.0 |
| | VGS | 14776 | Methane | 6.72E+03 | 5.54E+07 | 339.2 |