Offsite Consequence Analysis Requirements & Modeling

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Overview

- Regulatory Requirements
  - Applicability
  - Five Year Accident History
  - Offsite Consequence Analysis:
    - Worst and Alternative Case Scenarios
    - Offsite Impacts
- Modeling
  - Worst and Alternative Case Scenarios
  - Modeling techniques
    - Toxics
    - Flammables

Regulatory Requirements

- Applicability
  - Owner/operator of a Program 1 process must:
    - Prepare a worst-case release scenario analysis
    - Report the Five Year Accident History
  - Owner/operator of a Program 2 or 3 process must:
    - Prepare a worst-case and alternative release scenario analysis
    - Define offsite impacts (population and environment)
    - Report the Five Year Accident History

Regulatory Requirements

- Five Year Accident History
  - The release must be from a covered process and involve a regulated substance held above its threshold quantity in the process
  - Release must have caused at least one of the following
    - On-site deaths, injuries, or significant property damage; or
    - Known offsite deaths, injuries, property damage, environmental damage, evacuations, or sheltering in place

Regulatory Requirements

- Five Year Accident History
  - Report data surrounding the incident:
    - Date, time, and approximate duration
    - Identity of substance and quantity released
    - NAICS code for the process
    - Release event and its source
    - Weather conditions, if known
    - Onsite impacts and known offsite impacts
    - Initiating event and contributing factors
    - Whether offsite responders were notified
    - Operating and process changes made
  - Numerical estimates – report to two significant digits

Regulatory Requirements

- Offsite Consequence Analysis (OCA) – Worst Case
  - Endpoint to be used:
    - Toxic Substance: Endpoints are listed in Appendix A of the Regulation
      - Ammonia: 0.14 mg/L
      - Chlorine: 0.0087 mg/L
      - Sulfur Dioxide: 0.0078 mg/L
    - Flammable Substance: Overpressure of 1 psi for an explosion.

Regulatory Requirements

- Offsite Consequence Analysis (OCA) – Worst Case
  - Number of scenarios:
    - Toxic Substance: One scenario that is estimated to create the greatest distance in any direction to an endpoint resulting from a release of toxic substances from covered processes.
    - Flammable Substance: One scenario that is estimated to create the greatest distance in any direction to an endpoint resulting from a release of toxic substances from covered processes
    - Additional scenarios for a hazard class if a worst case release from another covered process at the stationary source potentially affects different public receptors

Regulatory Requirements

- Offsite Consequence Analysis (OCA) – Worst Case
  - Quantity released: Greatest amount held in single vessel or pipe
    - Administrative controls (procedures limiting amount)
  - Scenario type
    - Gas / Liquid / Solid
  - Meteorological conditions: F stability and 1.5 meters/second wind speed
  - Release height: Assume ground level release (0 feet)

Regulatory Requirements

- OCA – Worst Case Scenario
  - Duration: 10 minutes (Toxics only)
  - Determination of Release Rate (Toxics only)
  - Passive mitigation systems may be taken into account (building enclosure, containment berm, etc.)
    - The mitigation system must be capable of withstanding the release event triggering the scenario and would still function as intended.

Regulatory Requirements

- OCA – Worst Case Scenario
  - Surface roughness
    - Urban: Many obstacles (forest, hills, homes, buildings)
    - Rural: Flat, unobstructed
  - Modeling method to determine distance to endpoint: EPA RMP*Comp, EPA OCA Guidance, ALOHA, etc.

Regulatory Requirements

- OCA – Alternative Case Scenario
  - Endpoint to be used:
    - Toxics: Endpoints are listed in Appendix A of the Regulation
    - Flammables: Endpoints vary based on the selected scenario:
      - Explosion – Overpressure of 1 psi
      - Radiant heat / exposure time – 5 kw/m^2 for 40 seconds
      - Lower Flammability Limit (LFL) – Based on NFPA documents
  - Number of scenarios:
    - Toxics: Analyze at least one alternative release scenario for each regulated toxic substance.
    - Flammables: Analyze at least one alternative release scenario to represent all flammable substances.

Regulatory Requirements

- OCA – Alternative Case Scenario
  - Scenario selection:
    - More likely to occur than the worst-case scenario
    - Reach an endpoint offsite, unless no such scenario exists
    - Reach a public receptor, unless no such scenario exists
  - Factors in selecting the scenario:
    - Five year accident history
    - Accidents / incidents in related industry
    - Failure scenarios identified in the Hazard Review / Process Hazard Analysis

Regulatory Requirements

- OCA – Alternative Case Scenario
  - Scenarios – must consider the following:
    - Transfer hose releases due to splits or sudden hose uncoupling
    - Process piping releases from failures at flanges, joints, welds, valves and valve seals, and drains or bleeds
    - Process vessel or pump releases due to cracks, seal failure, or drain, bleed, or plug failure
    - Vessel overfilling and spill, or over pressurization and venting through relief valves or rupture disks
    - Shipping container mishandling and breakage or puncturing leading to a spill

Regulatory Requirements

- OCA – Alternative Case Scenario
  - Mitigation
    - Active: Emergency shut down systems, etc.
    - Passive: Building enclosure, containment berm, etc.
  - Meteorological conditions: Typical conditions in your area may be used
  - Surface Roughness
    - Urban: Many obstacles (forest, hills, homes, buildings)
    - Rural: Flat, unobstructed
  - Modeling method to determine distance to endpoint: EPA RMP*Comp, EPA OCA Guidance, ALOHA, etc.

Regulatory Requirements

- OCA – Offsite Impacts
  - Estimate the population affected
    - Most recent census data
    - Estimate to 2 significant digits
  - Identify receptors affected
    - Population receptors: Schools / child care facilities, hospitals / long term health care facilities, parks and recreational areas, etc.
    - Environmental receptors: National parks, state parks, wildlife sanctuaries, etc.
      - Use USGS Data
  - Mapping Software: MARPLOT, Google Earth, etc.

Regulatory Requirements

- OCA – Update Requirements
  - Every five years
  - Process change that may increase or decrease distance to TE by a factor of 2 or more
- OCA – Documentation
  - Worst case scenario:
    - A description of the vessel or pipeline and substance selected
    - Assumptions and parameters used, including administrative and passive mitigation controls to limit the quantity released and the effect of the controls
    - Rationale for selection

Regulatory Requirements

- OCA - Documentation
  - Alternative case scenario:
    - A description of the scenarios identified
    - Assumptions and parameters used, including any administrative controls and any mitigation that were assumed to limit the quantity that could be released and effect of the controls to the release rate and release quantity
    - Rationale for the selection of specific scenario

Regulatory Requirements

- OCA - Documentation
  - Documentation of estimated quantity released, release rate, and release duration
  - Methodology, including the model used to determine distance to endpoints
  - Data used to estimate population and environmental receptors potentially affected

Sample – Ammonia Refrigeration

- Ammonia Refrigeration System
- Amount in System: 8,000 pounds
- Toxic endpoint for ammonia: 200 ppm or 0.14 mg/L
- List of pressure vessels in system:

Pressure Vessel	Capacity	Location
High Pressure Receiver	9,000 pounds	Engine Room
Recirculator	7,000 pounds	Engine Room
Surge Drum	300 pounds	Roof

Sample – Ammonia Refrigeration

- Worst Case Release Scenario

Pressure Vessel	Capacity	Location
High Pressure Receiver	9,000 pounds	Engine Room
Recirculator	7,000 pounds	Engine Room
Surge Drum	300 pounds	Roof

- Largest vessel: High Pressure Receiver
- Administrative control: The High Pressure Receiver (9,000 lb capacity) can hold the entire system charge (8,000 lbs).
- Release Quantity: 8,000 pounds

Sample – Ammonia Refrigeration

- Passive mitigation: Engine Room 60,000 ft^3
- Verification that mitigation is capable of withstanding the release event:

According to the OCA Guidance, "As a rough rule of thumb, if the room volume (V) divided by the quantity of ammonia (Q) in the vessel is less than 0.1 ft^3/lb, there is a possibility that the release of ammonia will cause failures such as windows blowing out or doors blowing open."

$$\frac{Room\ Volume\ (V)}{Release\ Quantity\ (Q)} > 0.1\ ft^3/lb$$

$$\frac{60{,}000\ ft^3}{8{,}000\ lbs} = 7.5\ ft^3/lb > 0.1\ ft^3/lb$$

Sample – Ammonia Refrigeration

- Surface Roughness: Rural
- Conditions: F stability, 1.5 m/s wind speed
- Model: RMP Comp
  - Enter the above parameters into the model

Parameter	Input
Scenario type	Worst-case
Physical state	Gas release
Quantity	8,000 pounds
Surrounding terrain type	Rural
Mitigation measures	Engine Room

Errors Found

No errors found

Chemical Information

Chemical Name: Ammonia (anhydrous)

CAS Number: 7664-41-7

Chemical Type: Toxic Gas

Worst-case Analysis

Scenario type: (●) Worst-case ( ) Alternative

Physical state: ( ) Unliquefied
( ) Liquefied by refrigeration
(●) Liquefied under pressure

Quantity released: 8000 pounds

Surrounding terrain type: ( ) Urban (many obstacles in the immediate area)
(●) Rural (terrain generally flat and unobstructed)

Mitigation measures

Check the checkbox below if the following mitigation measure is in place in your process.

Release in enclosed space, in direct contact with outside air: ☑

Submit

Estimated Distance Calculation

Estimated distance to toxic endpoint: 1.2 miles (1.9 kilometers)

This is the downwind distance to the toxic endpoint specified for this regulated substance under the RMP Rule. Report all distances shorter than 0.1 mile as 0.1 mile, and all distances longer than 25 miles as 25 miles.

Scenario Summary

Chemical: Ammonia (anhydrous)

CAS number: 7664-41-7

Threat type: Toxic Gas

Scenario type: Worst-case

Physical state: Liquefied under pressure

Quantity released: 8000 pounds

Release duration: 10 min

Release rate: 440 pounds per minute

Mitigation measures: Release in enclosed space, in direct contact with outside air

Surrounding terrain type: Rural surroundings (terrain generally flat and unobstructed)

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

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)

Sample – Ammonia Refrigeration

- Alternative Case Release
- Scenarios to consider:
  - Five year accident history: None
  - Transfer hose release: Unlikely to happen as transfer hoses are used infrequently (ammonia deliveries, line opening)
  - Process piping release: Possible, this site has experienced small valve packing leaks in the past.
  - Process vessel or pump release: Possible, similar in consequences to piping release.
  - Vessel overfill and spill, or PRV venting: Ammonia unloading is monitored closely so vessel overfill is unlikely. All PRVs in the system vent to a diffusion tank.
  - Shipping container mishandling: Unlikely, ammonia is delivered by experienced drivers in properly maintained trucks.

Sample – Ammonia Refrigeration

- Release rate using guidance document (simplified version of Bernoulli Equation):

$$QR = HA \times 203 \times P_g^{1/2}$$

QR = Release rate (pounds/minute)

HA = Hole area (square inches)

203 = Constant based on discharge coefficienct, liquid density of ammonia, and conversion factor

P_g = Pressure of ammonia released (psig)

Sample – Ammonia Refrigeration

- Hole: ¼ inch
- P_g: 150 psig
- Release rate:

$$QR = 0.0491 \times 203 \times 150^{1/2}$$

$$QR = 122 \text{ lbs/min}$$

- Surface Roughness: Rural
- Conditions: D stability, 3 m/s wind speed
- Passive Mitigation: None, pipe is located outside.
- Active Mitigation & Release Duration: Emergency shutdown within 60 minutes

Sample – Ammonia Refrigeration

- Model: RMP Comp
  - Enter the above parameters into the model

Parameter	Input
Scenario type	Alternative-case
Physical state	Gas liquified by pressure
Release rate	User-specified, 122 lbs/min
Release duration	60 minutes
Surrounding terrain type	Rural
Mitigation measures	None

Errors Found

No errors found

Chemical Information

Chemical Name: Ammonia (anhydrous)

CAS Number: 7664-41-7

Chemical Type: Toxic Gas

Alternative Analysis

Scenario type: ○ Worst-case ◉ Alternative

Physical state: ○ Unliquefied ○ Liquefied by refrigeration ◉ Liquefied under pressure

Release rate calculation: ◉ User-specified ○ Estimated

Release rate: 122 pounds per min

Release duration: 60 minutes

Surrounding terrain type: ○ Urban (many obstacles in the immediate area) ◉ Rural (terrain generally flat and unobstructed)

Mitigation measures

Check the checkbox below if the following mitigation measure is in place in your process.

Release in enclosed space, in direct contact with outside air: ☐

Submit

Estimated Distance Calculation

Estimated distance to toxic endpoint: 0.2 miles (0.3 kilometers)

This is the downwind distance to the toxic endpoint specified for this regulated substance under the RMP Rule. Report all distances shorter than 0.1 mile as 0.1 mile, and all distances longer than 25 miles as 25 miles.

Scenario Summary

Chemical: Ammonia (anhydrous)

CAS number: 7664-41-7

Threat type: Toxic Gas

Scenario type: Alternative

Physical state: Liquefied under pressure

Release duration: 60 minutes

Release rate: 122 pounds per min

Mitigation measures: NONE

Surrounding terrain type: Rural surroundings (terrain generally flat and unobstructed)

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

Assumptions about this scenario

Wind speed: 3 meters/second (6.7 miles/hour)

Stability class: D

Air temperature: 77 degrees F (25 degrees C)

Sample – Ammonia Refrigeration

- Modeling using MARPLOT

Affected Population (from Marplot)
Worst: 199
Alternative: 0

Sample – Aqueous Ammonia

- Aqueous Ammonia SCR System (30% solution)
- Two tanks with 16,900 gallons (37,520 lbs) each
- Toxic endpoint for ammonia: 200 ppm or 0.14 mg/L
- Largest vessel: One storage tank
- Administrative control: Procedure to limit amount in the vessel to 80% (13,520 gallons or 30,041 lbs)
- Secondary containment: Berm (Surface Area 2,604 ft^2)

Sample – Aqueous Ammonia

- Worst Case Release

Pressure Vessel	Capacity	Containment
Storage Tank	30,041 pounds (80%)	Berm (2,694 ft^2)

- Note: *The dike can be considered as a passive mitigation measure, provided that the dike is capable of withstanding the release event triggering the scenario and would still function as intended. To verify this, the maximum area of the pool that would be formed (assuming a depth of one centimeter) was compared to the surface area of the dike.*

Sample – Aqueous Ammonia

- Calculate the Evaporation Rate

QR = 0.036 X Berm Surface Area

QR = Quantity Released

0.036 = Constant Based on 30% Aqua Ammonia Solution

QR = 0.036 X 2,604 ft^2 = 94 lbs/min

Sample – Aqueous Ammonia

- Temperature Correction

  Consider the release temperature to be the highest daily temperature observed during the last 3 years (or the operating temperature) whichever is highest.

  Highest Temperature: 104˚F (40˚C)

  $$QR = 0.036 \text{ X Berm Surface Area x } R_{vp}(T)$$

  $R_{vp}(T)$ = ratio of partial pressure of ammonia at T˚C to the partial pressure at 25˚C

  EPA OCA Guidance Document: $R_{vp}(T) = 1.72$

  $$QR = 0.036 \text{ X } 2{,}604 \text{ ft}^2 \text{ X } 1.72 = 161 \text{ lbs/min}$$

Sample – Aqueous Ammonia

- Passive Mitigation: None (Tanks are located outside)
- Surface Roughness: Urban
- Conditions: F stability, 1.5 m/s wind speed
- Distance to Toxic Endpoint:
  - EPA Guidance Document Tables / Equations
  - Dependent on Release Rate and Topography

Tables: Distance to TE = 0.3 Miles

Equations: Distance to TE = $0.0221 \times QR^{0.4712}$

Distance to TE = $0.0221 \times 161^{0.4712} = 0.25$ Miles

Sample – Aqueous Ammonia

- Alternative Case Release
- Scenarios to consider:
  - Five year accident history: None
  - Transfer hose release: Possible, deliveries using transfer hoses occur as needed.
  - Process piping release: Possible, all piping associated with the system is not insulated and are located outside.
  - Process vessel or pump release: Possible, similar in consequences to piping release.
  - Vessel overfill and spill, or PRV venting: Aqua ammonia deliveries are monitored closely so vessel overfill is unlikely. All PRVs in the system vent to atmosphere.
  - Shipping container mishandling: Unlikely, aqua ammonia is delivered by experienced drivers in properly maintained trucks.

Sample – Aqueous Ammonia

- Chosen scenario: piping/failed flange downstream of the forwarding pump.
- Hole Area: 0.5 inch
- Static Head: 10 feet
- Stability: D Class
- Wind Speed: 3 meters/second
- Mitigation: None (system located outside and assumed the leak would be uncontained)

Sample – Aqueous Ammonia

- Release rate using guidance document

$$RS = 153 \times HA \times SQRT(h)$$

RS = Rate of spillage onto the ground lbs/min)

HA = Hole area (square inches)

h = Static head

P_g = Pressure of ammonia released (psig)

RS = 153 x 0.2 x SQRT (10) = 95 lbs/min

Sample – Aqueous Ammonia

- Duration of release (t): 30 minutes (pump pressure alarm, onsite facility operators 24/7)
- Release amount

$$QS = RS \times t$$

$$QS = 95 \times 30 = 2{,}850 \text{ lbs}$$

2,850 lbs (Aqueous Ammonia 30%)

827 lbs (Ammonia)

- Evaporation Rate

$$QR = 0.025 \times QS = 0.025 \times 2{,}850 = 71 \text{ lbs / min}$$

Sample – Aqueous Ammonia

- Distance to Toxic Endpoint:
  - EPA Guidance Document Tables / Equations
  - Dependent on Release Rate and Topography

Tables: Distance to TE = 0.1 Mile

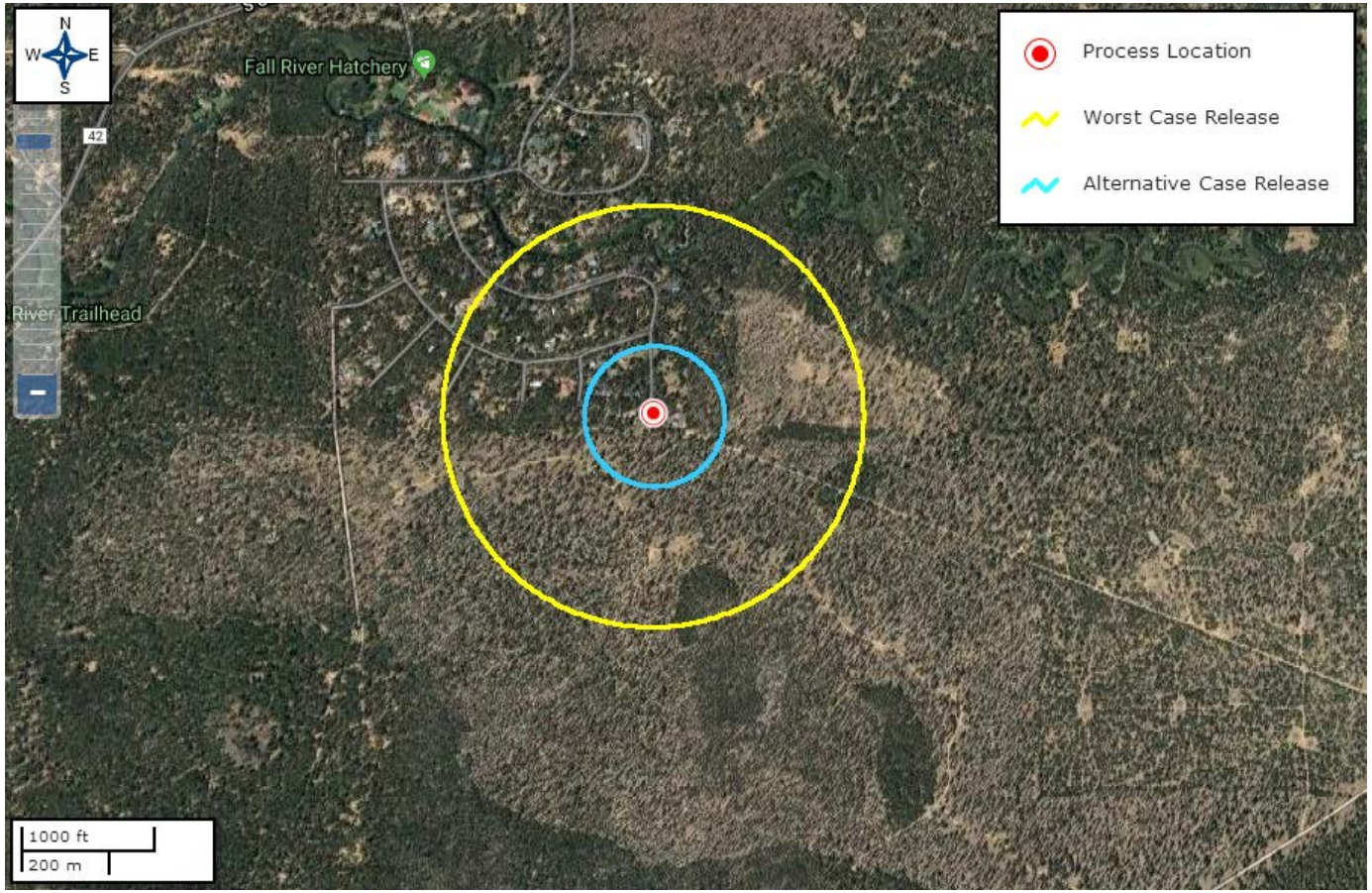
Equations: Distance to TE = $0.0107 \times QR^{0.4748}$

Distance to TE = $0.0107 \times 71^{0.4748} = 0.08$ Miles

Sample – Aqueous Ammonia

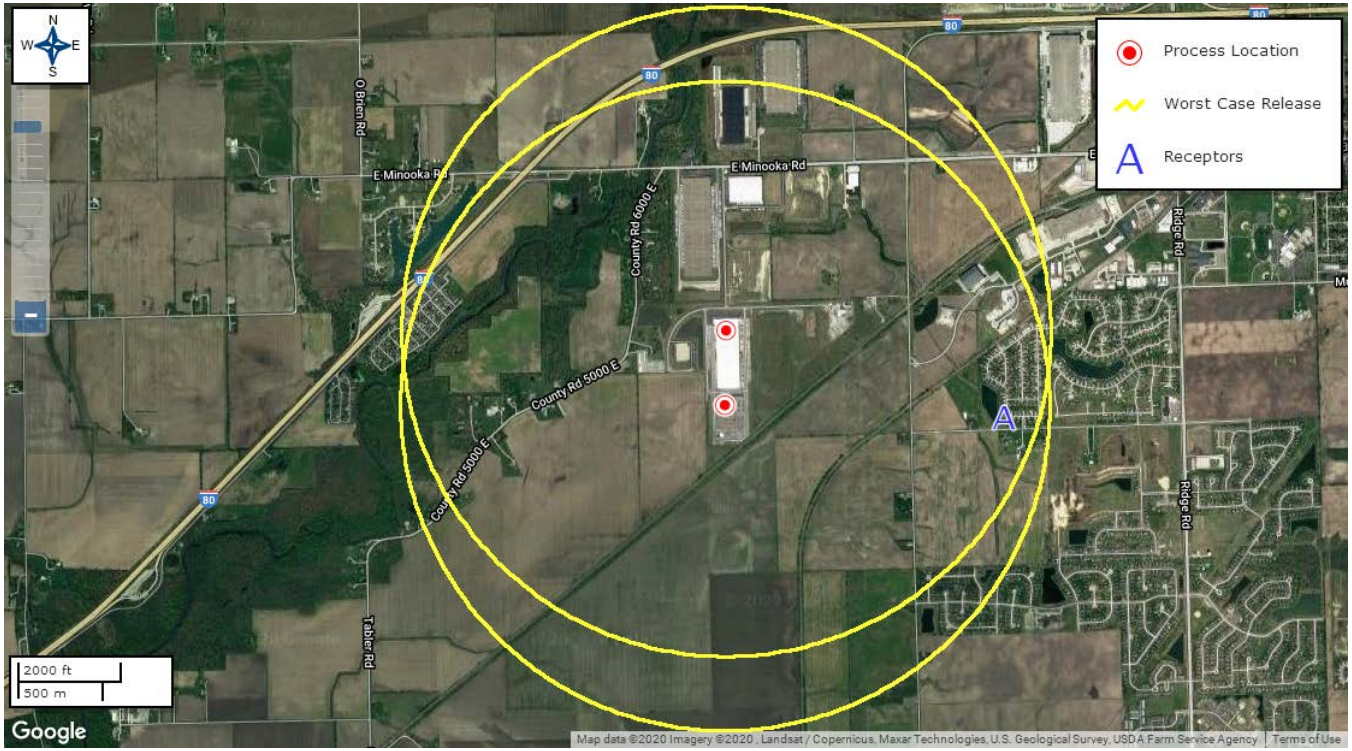
- Modeling using MARPLOT

Affected Population (from Marplot)
Worst: 0
Alternative: 0



Sample – Two Worst Case Scenarios

- Two processes
- Two initiating event locations



Sample – Flammable Substances

- Facility Location: Harrisburg, PA
- Facility has two covered processes, all located outside:
  - Propane transfill process
  - Isobutane transfill process
- Worst-case scenario: Vapor cloud explosion (required by regulation
- Worst-case flammable endpoint: 1 psi overpressure

Sample – Flammable Substance

- Worst-Case Release Quantity:

Storage Tank	Capacity (at 80%)	Location
Propane Bulk Tank	63,000 pounds	Outside
Isobutane Bulk Tank	85,000 pounds	Outside

- Administrative controls: Each storage tank is filled to a maximum of 80% of its capacity.
- Passive mitigation: None, all three processes are located outside.

Sample – Flammable Substance

- Release rate: All three substances are gases at ambient temperature and handled as a liquid under pressure. Therefore, the release rate is:

$$Release\ Rate = \frac{Quantity\ Released}{10\ minutes}$$

Storage Tank	Qty Released	Release Rate
Propane Bulk Tank	63,000 pounds	6,300 lbs/min
Isobutane Bulk Tank	85,000 pounds	8,500 lbs/min

Sample – Flammable Substance

- Surface Roughness: Rural
- Conditions: F stability, 1.5 m/s wind speed
- Model: ALOHA
- Enter the following parameters into ALOHA for each chemical:
  - Site Data:

Parameter	Input
Location	Harrisburg, PA
Building type	Single storied building
Building surroundings	Unsheltered surroundings

Sample – Flammable Substance

- Set Up:

Parameter	Input
Chemical	Selected for each chemical
Atmospheric options – user input	Wind speed: 1.5 m/s Wind is from: NW Wind measurement height: SAM station icon Ground roughness: Open country (rural) Cloud cover: Partly cloudy Air temperature: 77°F Stability class: F Inversion height options: No inversion Humidity: Medium (50%)

Sample – Flammable Substance

- Set Up (continued):

Parameter	Input
Source – Direct	Units: Pounds Instantaneous or continuous: Continuous Amount of pollutant: Enter release rate. Duration: 10 minutes Source height: 0 feet
Calculation options:	Let ALOHA decide.

Sample – Flammable Substance

- Display:

Parameter	Input
Threat Zone	Hazard to analyze: Blast area of vapor cloud explosion Time of vapor could ignition: Unknown Type of vapor cloud ignition: Ignited by detonation Overpressure level of concern: • Red threat zone LOC: 1 psi = shatters glass • Orange threat zone LOC: None • Yellow threat zone LOC: None

Sample – Flammable Substance

Chemical: Propane

Distance to endpoint: 873 yards = 0.50 miles

Text Summary

```
SITE DATA:
  Location: HARRISBURG, PENNSYLVANIA
  Building Air Exchanges Per Hour: 0.38 (unsheltered single storied)
  Time: February 3, 2020  1623 hours EST (using computer's clock)

CHEMICAL DATA:
  Chemical Name: PROPANE
  CAS Number: 74-98-6                    Molecular Weight: 44.10 g/mol
  AEGL-1 (60 min): 5500 ppm   AEGL-2 (60 min): 17000 ppm   AEGL-3 (60 min): 33000 ppm
  IDLH: 2100 ppm     LEL: 21000 ppm      UEL: 95000 ppm
  Ambient Boiling Point: -44.2° F
  Vapor Pressure at Ambient Temperature: greater than 1 atm
  Ambient Saturation Concentration: 1,000,000 ppm or 100.0%

ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)
  Wind: 1.5 meters/second from NW at 3 meters
  Ground Roughness: open country         Cloud Cover: 5 tenths
  Air Temperature: 77° F
  Stability Class: F (user override)
  No Inversion Height                    Relative Humidity: 50%

SOURCE STRENGTH:
  Direct Source: 6300 pounds/min         Source Height: 0
  Release Duration: 10 minutes
  Release Rate: 6,300 pounds/min
  Total Amount Released: 63,000 pounds
  Note: This chemical may flash boil and/or result in two phase flow.

THREAT ZONE:
  Threat Modeled: Overpressure (blast force) from vapor cloud explosion
  Type of Ignition: ignited by detonation
  Model Run: Heavy Gas
  Red    : 873 yards --- (1.0 psi = shatters glass)
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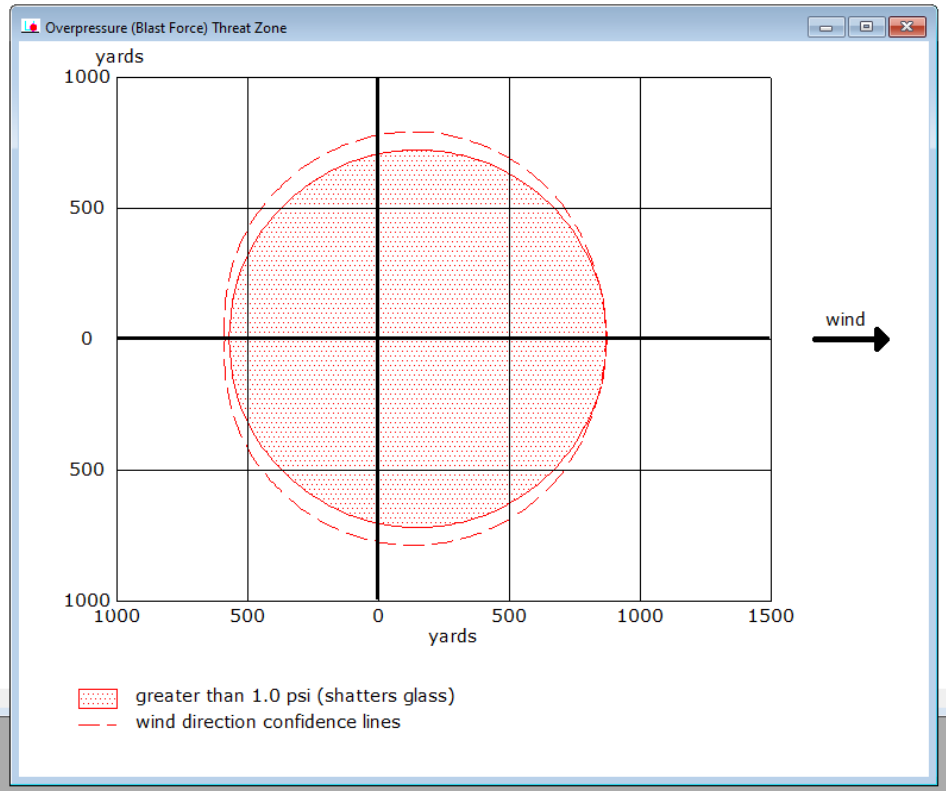

Sample – Flammable Substance

Chemical: Isobutane

Distance to endpoint: 1,024 yards = 0.58 miles

Text Summary

```
SITE DATA:
  Location: HARRISBURG, PENNSYLVANIA
  Building Air Exchanges Per Hour: 0.38 (unsheltered single storied)
  Time: February 3, 2020  1623 hours EST (using computer's clock)

CHEMICAL DATA:
  Chemical Name: ISOBUTANE
  CAS Number: 75-28-5                    Molecular Weight: 58.12 g/mol
  PAC-1: 5500 ppm     PAC-2: 17000 ppm    PAC-3: 53000 ppm
  LEL: 18000 ppm      UEL: 84000 ppm
  Ambient Boiling Point: 10.9° F
  Vapor Pressure at Ambient Temperature: greater than 1 atm
  Ambient Saturation Concentration: 1,000,000 ppm or 100.0%

ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)
  Wind: 1.5 meters/second from NW at 3 meters
  Ground Roughness: open country         Cloud Cover: 5 tenths
  Air Temperature: 77° F
  Stability Class: F (user override)
  No Inversion Height                    Relative Humidity: 50%

SOURCE STRENGTH:
  Direct Source: 8500 pounds/min         Source Height: 0
  Release Duration: 10 minutes
  Release Rate: 8,500 pounds/min
  Total Amount Released: 85,000 pounds
  Note: This chemical may flash boil and/or result in two phase flow.

THREAT ZONE:
  Threat Modeled: Overpressure (blast force) from vapor cloud explosion
  Type of Ignition: ignited by detonation
  Model Run: Heavy Gas
  Red   : 1024 yards --- (1.0 psi = shatters glass)
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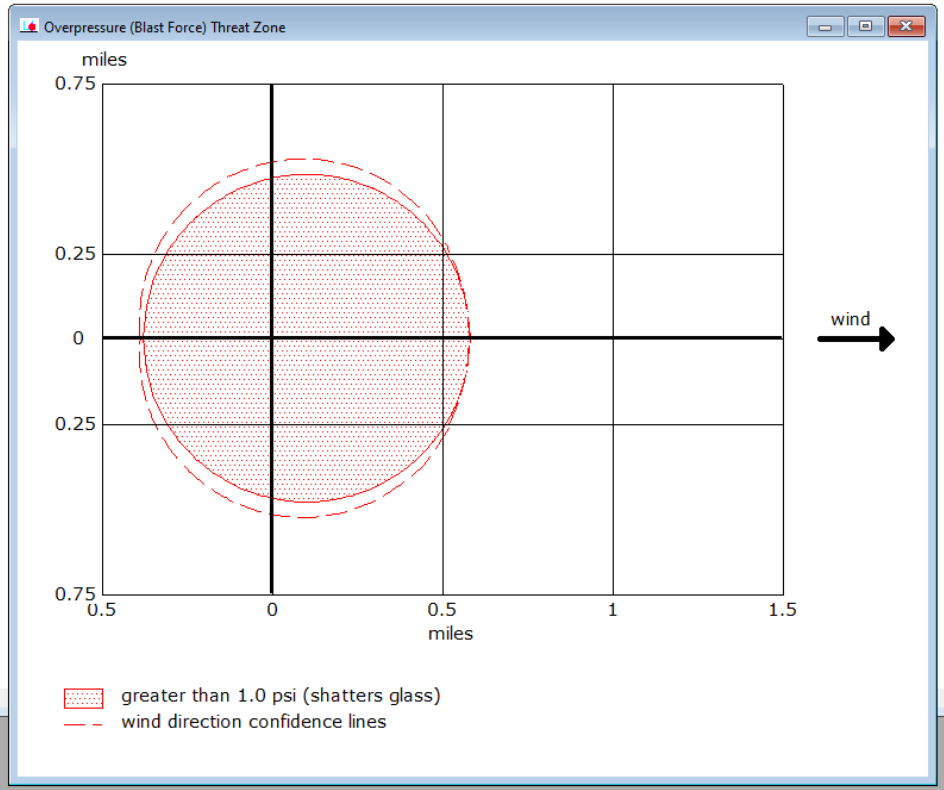


Sample – Flammable Substance

- Alternative Case Release
- Number of scenarios: One scenario to represent both propane and isobutane
- Meteorological conditions: D stability, 3 meters per second wind speed
- Surface Roughness: Rural
- Release Height: For a conservative approach, a ground level release (0 feet) was assumed.

Sample – Flammable Substance

- Scenarios to consider:
  - Five year accident history: None
  - Transfer hose release: Possible, this site has experienced small cylinder valve leaks at the hose connection point.
  - Process piping release: Possible, this site has experienced small cylinder valve leaks in the past.
  - Process vessel or pump release: Unlikely to happen, pressure vessel is inspected for corrosion.
  - Vessel overfill and spill, or PRV venting: Cylinder weight is monitored closely so cylinder overfill is unlikely.
  - Shipping container mishandling: Unlikely, facility has procedures for properly handling cylinders. Caps are installed on all cylinders after being filled.

Sample – Flammable Substance

- Selected scenario: Small (0.1-inch hole) leak on the cylinder valve connection resulting in a vapor cloud fire. A release of propane will be modeled since the facility fills more propane cylinders than isobutane cylinders.
- Release rate using EPA's RMP Guidance for OCA:

$$RR = HA \times P \times \frac{1}{\sqrt{T}} \times GF$$

RR = Release rate (pounds/minute)

HA = Hole area (square inches)

P = Tank or cylinder pressure (psia)

GF = Gas Factor (22 for propane)

T = Tank / cylinder temperature (kelvin, K)

Sample – Flammable Substance

- From Process Safety Information:
  - Propane cylinder is at a pressure of 124 psig (138.7 psia).
  - Propane cylinder is at ambient temperature (77°F or 298 K).
- Release rate is calculated:

$$RR = 0.00785 \times 138.7 \times \frac{1}{\sqrt{298}} \times 22 = 1.39\ lbs/min$$

- Mitigation:
  - Passive: None, process is outside.
  - Active: Emergency shut down of system within 60 minutes.
- Release duration: 60 minutes
- Flammable endpoint: Lower Flammability Limit for vapor cloud fires – 36 mg/L (2.1% volume) for propane

Sample – Flammable Substance

- Model: ALOHA
- Enter the following parameters into ALOHA for each chemical:
  - Site Data:

Parameter	Input
Location	Harrisburg, PA
Building type	Single storied building
Building surroundings	Unsheltered surroundings

Sample – Flammable Substance

- Set Up:

Parameter	Input
Chemical	Propane
Atmospheric options – user input	Wind speed: 3 m/s Wind is from: NW Wind measurement height: SAM station icon Ground roughness: Open country (rural) Cloud cover: Partly cloudy Air temperature: 77°F Stability class: D Inversion height options: No inversion Humidity: Medium (50%)

Sample – Flammable Substance

- Set Up (continued):

Parameter	Input
Source – Direct	Units: Pounds Instantaneous or continuous: Continuous Amount of pollutant: 1.39 lbs/min Duration: 60 minutes Source height: 0 feet
Calculation options:	Let ALOHA decide.

Sample – Flammable Substance

- Display:

Parameter	Input
Threat Zone	Hazard to analyze: Flammable area of vapor cloud Overpressure level of concern: • Red threat zone LOC: 21,000 ppm = LEL = LFL • Orange threat zone LOC: None • Yellow threat zone LOC: None

Sample – Ammonia Refrigeration

- RMP Comp
  - Enter the above parameters into the model

Parameter	Input
Scenario type	Alternative-case
Physical state	Gas liquified by pressure
Release rate	User-specified, 122 lbs/min
Release duration	60 minutes
Surrounding terrain type	Rural
Mitigation measures	None

Sample – Flammable Substance

Chemical: Propane

Distance to endpoint: 12 yards = 0. 0068 miles (rounded to 0.01 mile)

Text Summary

```
SITE DATA:
  Location: HARRISBURG, PENNSYLVANIA
  Building Air Exchanges Per Hour: 0.66 (unsheltered single storied)
  Time: February 3, 2020  1835 hours EST (using computer's clock)

CHEMICAL DATA:
  Chemical Name: PROPANE
  CAS Number: 74-98-6                    Molecular Weight: 44.10 g/mol
  AEGL-1 (60 min): 5500 ppm   AEGL-2 (60 min): 17000 ppm   AEGL-3 (60 min): 33000 ppm
  IDLH: 2100 ppm     LEL: 21000 ppm      UEL: 95000 ppm
  Ambient Boiling Point: -44.2° F
  Vapor Pressure at Ambient Temperature: greater than 1 atm
  Ambient Saturation Concentration: 1,000,000 ppm or 100.0%

ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)
  Wind: 3 meters/second from NW at 3 meters
  Ground Roughness: open country         Cloud Cover: 5 tenths
  Air Temperature: 77° F                 Stability Class: D
  No Inversion Height                    Relative Humidity: 50%

SOURCE STRENGTH:
  Direct Source: 1.39 pounds/min         Source Height: 0
  Release Duration: 60 minutes
  Release Rate: 1.39 pounds/min
  Total Amount Released: 83.4 pounds
  Note: This chemical may flash boil and/or result in two phase flow.

THREAT ZONE:
  Threat Modeled: Flammable Area of Vapor Cloud
  Model Run: Heavy Gas
  Red   : 12 yards --- (21000 ppm = LEL)
  Note: Threat zone was not drawn because effects of near-field patchiness
    make dispersion predictions less reliable for short distances.
  Yellow: 13 yards --- (2100 ppm = 10% LEL)
  Note: Threat zone was not drawn because effects of near-field patchiness
    make dispersion predictions less reliable for short distances.
```

Flammable Threat Zone

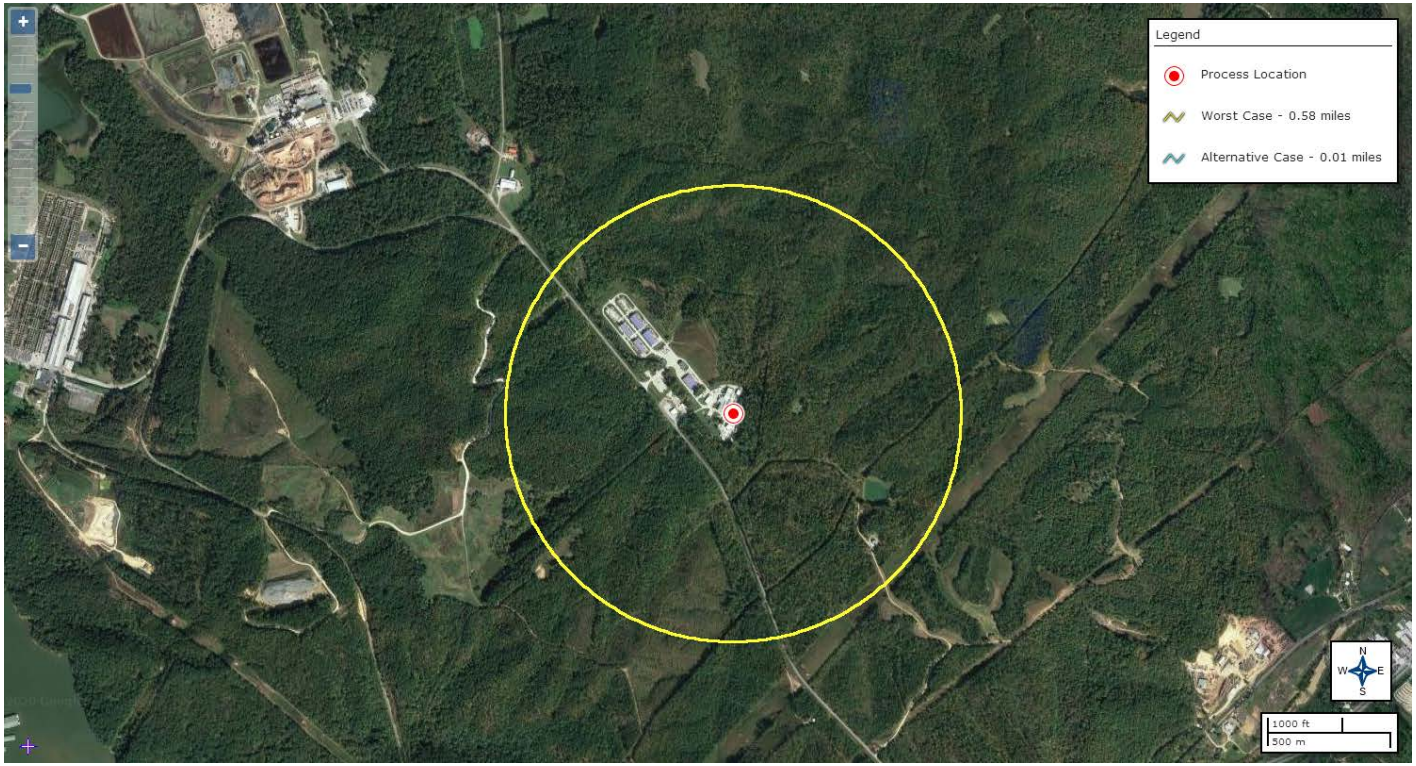
Threat Modeled: Flammable Area of Vapor Cloud
Model Run: Heavy Gas
Red : 12 yards --- (21000 ppm = LEL)
Note: Threat zone was not drawn because effects of near-field patchiness make dispersion predictions less reliable for short distances.
Yellow: 13 yards --- (2100 ppm = 10% LEL)
Note: Threat zone was not drawn because effects of near-field patchiness make dispersion predictions less reliable for short distances.

Sample – Flammable Substance

- Modeling using MARPLOT
- Worst Case:

Chemical: Isobutane

Affected Population: 0 (from Marplot)



Sample – Flammable Substance

- Modeling using MARPLOT
- Alternative Case:

Chemical:
Propane
Affected
Population: 0
(from Marplot)