Class-2 Hazmat Transportation Consequence Assessment On Surrounding Population

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Introduction

- Transportation of hazardous materials through various modes is an utmost necessity, but inherently dangerous.

- En-route accidents that result in a release can create inhalation problems or could lead to fires and explosions.
Hazards of Class-2 Hazmat Transportation

- Transport Incidents involving Class-2 hazmats, can lead to BLEVE or an Un-confined Vapor Cloud Explosion (UVCE), because of their storage conditions.

- Hazmats studied are LPG, Ethylene Oxide, Propylene, 1,3 Butadiene and Ammonia.
Study Area

- Assessment studies carried out for two State Highway segments passing through important industrial corridors of Surat in western India.

- 29 Major Accident Hazard industrial units handling 35 hazmats from 4 UN categories of hazmats, namely class-2, class-3, class-6 and class-8.
Consequence Assessment

It considers two kinds of scenarios:

- A Worst-Case Scenario (WCS), and
- Alternative Case Scenarios (ACSs).

Effects studied are Fire & Explosion and Toxicity.

Hazmats studied: 1,3 Butadiene and Ammonia and compared with other Class-2 hazmats.
Scenarios

BLEVE and UVCE studied for LPG, Ethylene Oxide, Propylene and 1,3 Butadiene. For Ammonia, only BLEVE scenario is considered.

Jet fire, pool fire and toxic endpoints considered for the ACSs i.e. for releases based on hole size (large or medium liquid or vapor).
Fire & Explosion Consequences

- Flammability endpoints considered: fatality, structural damage, 2nd degree and 1st degree burns for BLEVE.

- For UVCE, endpoints are fatality, structural damage, ear drum damage, missile damage and glass break distances.

- Software used: HAMS-GPS – an Indian software
BLEVE Effects of Class-2 Hazmats

- Outcome events considered for estimating damage distances are:
  - Explosion, Fireball and Flash fires

- Damage criteria are:
  - Fatality, 2\textsuperscript{nd} degree burn, 1\textsuperscript{st} degree burn and structural damage

- Largest distance is for fireball scenario compared to explosion and flash fires.
UVCE Consequences

- Outcome events considered for estimating damage distances are:
  - Explosion overpressure

- Damage criteria are:
  - Fatality, structural damage, ear-drum damage, missile limit and glass-break.
Toxic Consequences

For toxic endpoints:

- lethality distances (100%, 50%, 1%),
- IDLH,
- ERPG-3,
- ERPG-2, and
- ERPG-1

Software used: ALOHA of US EPA
Site-specific Meteorology

- Most predominant wind direction: South-West; Stability class: D(Neutral)
- Annual average wind speed: about 2 m/s.
- 50% humidity and 7/10th cloud cover.
- Circular impact area is considered for BLEVE and a plume for toxic dispersion.
Toxic Effect Distances (Ammonia)

For Ammonia (15 MT), concentration-effect distances are (rupture case):

- 100% lethality - 8519 ppm - 0.639 km
- 50% lethality - 4005 ppm - 0.839 km
- 1% lethality - 1883 ppm - 1.1 km
- ERPG-3 - 750 ppm - 1.5 km
Toxic Effect Distances ....Contd...

- **IDLH** - 300 ppm - 2.1 km
- **ERPG-2** - 150 ppm - 2.7 km
- **ERPG-1** - 25 ppm - 5.1 km

For 10 MT ammonia, the distances are: 0.550, 0.726, 0.949, 1.3, 1.8, 2.3 and 4.4 km respectively.
Toxic Effect Distances (17.5 MT 1,3 Butadiene)

- Concentration -effect distances are (rupture case):
  - 50% lethality: 129000 ppm - 0.094 km
  - 1% lethality: 41000 ppm - 0.233 km
  - ERPG-3: 5000 ppm - 0.661 km
  - IDLH: 2000 ppm - 0.940 km
  - ERPG-2: 200 ppm - 2.2 km
  - ERPG-1: 10 ppm - 7.0 km
Alternate – Case Scenarios

- Leak sizes of 100 mm and 25 mm for large and medium vapor leaks, chosen for ammonia releases, because of their higher probability of occurrences.

- However, hole sizes of 1, 3 Butadiene are 50 mm for large vapor and liquid leaks and 25 mm for medium liquid leak for a definite duration.
Out of three leak scenarios, large liquid leak (50 mm) causes greater distances than from a large vapor leak (50 mm) in cases of jet fire and flash fire scenarios, because of rapid expansion of released liquid.

Toxic effect distances for different endpoints also show similar patterns.
Toxic Effect Distances for ACSs (Ammonia)

- Out of two leak scenarios, large vapor leak (100 mm) causes greater distances than medium vapor leak (25 mm) for all the toxic end points.

- However, higher tanker capacity will cause greater effect distances than the smaller one for similar leak and release scenarios.
GIS Mapping
(Worst-case-BLEVE Distances)
GIS Mapping (Rupture Case)
Toxic Distances - Ammonia
GIS Mapping (Rupture Case)
Toxic Distances - 1,3 Butadiene
Vulnerable Zones (under Worst-Cases)

- Estimated flammable vulnerability zone for 1,3 Butadiene (17.5 MT) is 0.138 km$^2$ against 0.604 km$^2$ for ammonia (15 MT).

- Estimated toxic vulnerability Zone for 1,3 Butadiene (17.5 MT) is 0.053 km$^2$ against 0.076 km$^2$ in case of ammonia.
Conclusion

- BLEVE fatality distance generally in the order of Propylene > LPG > Ammonia > Ethylene oxide > 1-3 Butadiene and so are the 2\textsuperscript{nd} and 1\textsuperscript{st} degree burn distances.

- For UVCE effects, it is Propylene > LPG > 1-3 Butadiene > Ethylene oxide.
Conclusion ---contd.

- Lethality distances (1%) for 10 MT ammonia and 17.5 MT of 1, 3 Butadiene is around 1 km and 0.23 km respectively.

- IDLH distances vary as chlorine > ammonia > ethylene oxide > 1-3 Butadiene.
Conclusion ---contd.

- ERPG-3, ERPG-2 and ERPG-1 distances will be useful for planning emergency actions.

- Vulnerable zones estimated with regard to each worst case scenario may be used for evacuation purposes in the study area.
THANKS