# Risk Mitigation Measure on Hazardous Chemical Tanker Truck Accident Happened in the Road Highway

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***Abstract*—Recently transportation of the hazardous chemical form the road like National and State highway is very dangerous to people & traffic system. Highway accidents involving chemicals often lead to severe injuries, environmental damage, and long-term consequences. In this paper, we study on the how to mitigate risk if any carry hazardous chemical tank truck accident on the highway. Commonly Transported Hazardous Materials are Petroleum Products like Petrol, Diesel, LPG, Naphtha and Gases/liquefied gases such as ammonia, chlorine. Simulation and consequence analysis part was done by using ALOHA software by calculating the damage distances of the hazardous chemical leakage from the tank truck if meet any ignition source. Based consequence analysis we concluded the risk mitigation. Further analysed and suggest in the research paper best way to evacuate the people from any accident happened suddenly. The method presented in this paper can serve as a theoretical reference for predicting the development of accidents and clarifying their consequences.**

***Index Terms*—Hazardous Materials (Hazmat), ALOHA Software, Consequence Analysis, Risk Mitigation, Tank Truck Accidents, Emergency Evacuation, Highway Safety**

## I. INTRODUCTION

Road accidents involving hazardous chemical releases (hazmat spills) often involve tanker rollovers or collisions, resulting in fire, explosions, and toxic leaks. These incidents commonly occur due to driver error, vehicle failure, or severe weather, frequently leading to major road closures, large-scale evacuations, and severe long-term injuries or fatalities. The majority of hazmat accidents occur on roads, with over 60% being single-vehicle accidents often caused by driver error or vehicle malfunction. Frequently spilled materials include flammable substances like propeller gas, gasoline, diesel oil, and liquefied petroleum gas (LPG). The primary dangers are leaks (up to 80% of incidents), fires, and explosions. Tanker Truck Vehicular fluid spills are releases of materials that are used in a vehicle's operation. The size of the release is usually small and limited to the amount used in vehicle operations.

In India, National Highways showed an 11% decline from 2024 to 2025, accidents involving commercial trucks and hazardous materials remain a critical concern. Experts and platforms like The Logical Indian have noted that long hours, driver fatigue, and inadequate emergency infrastructure for handling chemical leaks contribute to these prolonged highway crises.

## II. RESEARCH METHOD

ALOHA (Areal Locations of Hazardous Atmospheres) software is a critical tool for modelling chemical releases, calculating threat zones (toxic, flammable, explosive), and determining downwind dispersion for emergency response planning and quantitative risk assessment. A threat zone is an area where a hazard (such as toxicity) has exceeded a user-specified Level of Concern (LOC). ALOHA is part of the CAMEO® software suite of products for emergency responders and planners.

Key Uses of ALOHA Software

- Hazardous Release Modelling: Simulates scenarios involving toxic gas clouds, flammable gas clouds, pool fires, jet fires, and vapor cloud explosions.
- Threat Zone Mapping: Predicts the area of impact (red, orange, and yellow zones) for chemical releases, allowing for the estimation of population

risk and the identification of vulnerable locations like schools or hospitals.

- Quantitative Risk Assessment (QRA): Used to assess the impact of industrial incidents, such as tank leaks (e.g., ethanol, chlorine) or pipeline ruptures.
- Environmental & Safety Compliance: Evaluates the safety of storing or using hazardous materials by analysing the consequences of potential incidents for regulatory compliance.

## III. SIMULATION OF TANK CAR LEAKAGE AND EXPLOSION ACCIDENT BY USING ALOHA SOFTWARE

In our study, recent reports show several hazardous tanker accidents on Indian highways, ranging from chemical spills to massive gas explosions:

Major Recent Incidents (2026)

- Jaipur–Kota Highway (April 2026): An oil tanker collided with a truck near Tonk, Rajasthan, leading to a massive leak of mustard oil across the road. Locals reportedly gathered with buckets and bottles to collect the spilled oil, ignoring safety risks and further slowing traffic.
- Mumbai–Ahmedabad Highway (April 2026): A gas tanker believed to be carrying hazardous butyric acid overturned in Palghar district. The accident, caused by over speeding, led to major traffic disruptions, though no casualties were reported at the time.
- Mumbai–Pune Expressway (February 2026): A Bharat Petroleum tanker carrying highly flammable propylene gas overturned near the Adoshi Tunnel in the Khandala ghat. This caused a historic 32-hour gridlock, stranding thousands of commuters in a 25-km tailback. A similar incident involving another propylene tanker occurred on the same route later that month but was cleared quickly as no leakage was found.
- Delhi–Jaipur Highway (February 2026): A tanker carrying hydrogen peroxide collided head-on with a truck near Antela. Two people were injured, and the hazardous chemical spill forced authorities to cordon off the area, causing massive traffic queues on National Highway 48.
- Jaipur–Delhi Highway (January 2026): A chemical-laden tanker collided with a trailer near Pavta, triggering a massive fire and a high explosion risk.

We are simulation of the incident happened in Maharashtra Propylene Spill, A tanker carrying propane overturned, creating an explosion risk and shutting down traffic on a major highway.

Propylene Gas Tanker Capacity:

Propylene transport tankers generally range from 15 to 25 metric tons (MT) for road tankers, while marine vessels are much larger.

- Common Road Tanker Capacity: 21 MT, 18 MT, 12.6 MT, and 7.5 MT are standard capacities in the industrial sector.
- Volume Capacity: Road tankers can have a volume of 50,000 Liters, with shell thicknesses ranging from 12mm to 14mm to withstand pressure.
- Design Specifications: These tankers are generally made of Carbon Steel or Stainless Steel (e.g., Q370R steel) and adhere to ASME Section VIII Division 1 or equivalent standards.
- Pressure Management: Tankers typically operate at pressures of 1.61 MPa to 2.0 MPa.

Propylene Composition and Characteristics

Propylene C3H6 is a colourless gas that is typically transported in its liquified form under pressure.

- Purity: Propylene is transported in different grades depending on its end use, with the most common being Polymer Grade (>99.5% pure) and Refinery Grade (50-70%) pure.
- Chemical Formula: (C3H6) (Propene).
- Liquid Density: Approx. (613.9 kg/m3) at 15°C.
- Boiling Point: (-47.6 Degree Celsius) (at 1.013 bar).
- Hazards: Highly flammable, but not toxic. Propylene gas is heavier than air, which means it can settle in low spots, presenting a risk of explosion.
- Safety Features: Tankers often carry only 80–85% of their total volume to allow for thermal expansion of the liquid.

ALOHA Software Simulation Results:

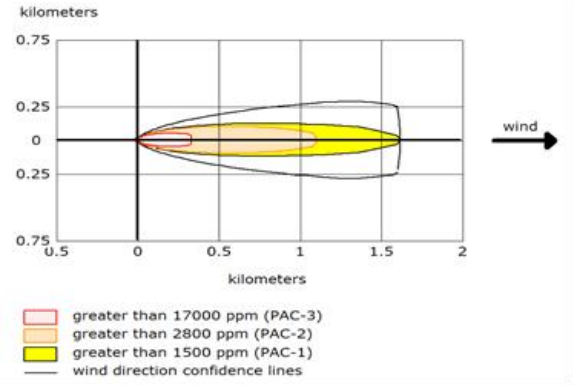


Figure 1. Toxic Threat Zone of the Propylene Tanker in Case of Leakage

Figure 1 Shows that, Propylene gas spread in the atmoshphere from tanker in case of leakage at the distance of Red: 332 meters (17000 ppm = PAC-3); Orange: 1.1 kilometres (2800 ppm = PAC-2); Yellow: 1.6 kilometres (1500 ppm = PAC-1)

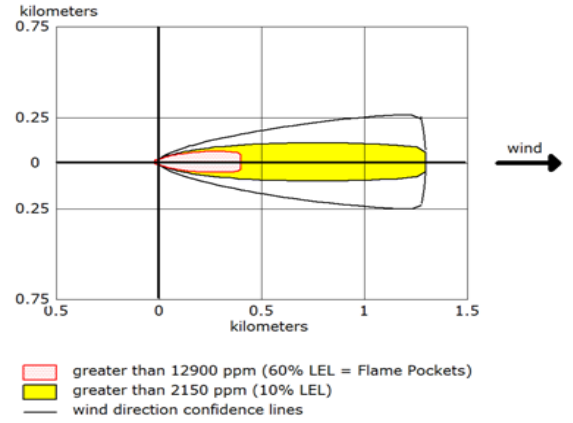


Figure 2. Flammable Area of Vapor Cloud of the Propylene Tanker in Case of Leakage

Figure 2 Shows that, Propylene gas exploded in the atmosphere from tanker in case of leakage at the distance of Red: 402 meters (12900 ppm = 60% LEL = Flame Pockets); Yellow: 1.3 kilometres (2150 ppm = 10% LEL)

## IV. RISK MITIGATION OF THE TANK TRUCK ACCIDENT & EMERGENCY EVACUATION & HIGHWAY SAFETY

Risk mitigation for tank truck accidents in India focuses on a multi-layered approach involving stricter regulations, advanced technology, driver training, and improved emergency response, aimed at reducing human error and equipment failure. With 80% of accidents attributed to over-speeding and driver error, and 930 deaths reported in 705 petroleum transport accidents between 2014-2019, the focus is on proactive prevention and robust emergency handling.

Mandatory Technology Upgrades:

- ADAS Mandate: From April 1, 2026, heavy vehicles (including tank trucks) must have Advanced Driver Assistance Systems (ADAS), including Advanced Emergency Braking Systems (AEBS), Driver Drowsiness Alert Systems (AIS-184), and Lane Departure Warning Systems (AIS-188).
- Vehicle Tracking System (VTS)/GPS: Mandatory 24/7 monitoring of POL (Petroleum, Oil, and Lubricant) tankers to monitor speed and route adherence.
- Safety Fittings: Trucks are required to have anti-lock braking systems (ABS), emergency shut-off valves, and specialized fire extinguishers.
- Electronic Stability Control (ESC): Mandatory implementation of ESC to improve stability at curves, effective for trucks by Oct 2027.

Regulatory & Operational Controls:

- Driver Training: Mandating specialized training (under Rule 9 of CMVR) for hazardous goods transporters, focusing on defensive driving and emergency handling.
- Fatigue Management: Regulatory changes include mandated AC cabins to reduce driver fatigue and new protocols for rest stops.
- Stricter Inspections: Periodic, mandatory inspections of tanker fitness (Type A check every 6 months) to identify defects in braking, steering, and suspension.
- Licensing Scrutiny: Enhanced vetting for issuing licenses to drivers transporting dangerous goods.

Emergency Response & Infrastructure:

- Guidelines: Guidelines are in place for the safe transportation of POL tankers, focusing on on-site and off-site emergency plans, safety audits, and public awareness.
- Emergency Response Teams (ERT): Quick reaction teams are deployed to incidents to handle spills, fire, or explosions.

- Mutual Aid: Establishing collaborations between petroleum companies for mutual aid assistance in case of road emergencies.
- Safety Infrastructure: Improving road design, installing crash barriers, and ensuring proper lighting on highways.

## V. CONCLUSION

This work highlights several critical aspects of risk management and preventive measures in hazardous chemical transportation. These insights provide a strong foundation for improving safety and reducing potential incidents.

1. The activities such as driving through significant roads, narrow bridges, and accident-prone zones contribute to high risk. The specific preventive measures, including real-time monitoring through geofencing, periodic training to workers and maintaining their competency, and chemical-specific emergency rescue planning and training, significantly reduced the risk of hazardous chemical transportation.
2. The dispersion study shows that on leakage, propylene is perceived across 1.3 km to 1.6 km along the wind direction, which requires a fast response from the drivers to reduce its impact on people and the environment. It requires fire-fighting facilities of the transportation tankers be sturdy and the workers acted quickly. The drivers must be trained in handling and containing more significant releases of hazardous chemicals.
3. The controls such as geofencing for in-vehicle monitoring are implemented to reduce the high-risk activities as low as possible. It is also essential to select traffic routes, assess prior trip risk, and ensure emergency response equipment's functionality. After implementing this program, accidents dropped from in years. With each successful trip, accidents can be eliminated, and the company's reputation will be improved.

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