MIST EXPLOSIONS INCIDENT SURVEY

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ATEX (user) Directive:

“explosive atmosphere” means a mixture, under atmospheric conditions, of air and one or more dangerous substances in the form of gases, vapours, mists or dusts in which, after ignition has occurred, combustion spreads to the entire unburned mixture”

DSEAR ACOP, paragraph 145:

"Some substances do not form explosive atmospheres unless they are heated, and some liquids if released under pressure will form a fine mist that can explode even if there is insufficient vapour."

Rolf Eckhoff [1]

“Published reports on accidental spray or mist explosions, apart from crank case explosions in ship engines, are scarce.”

Similar comments in other references

- 2008 Literature survey carried out by HSE library

Databases used:

- **Chemical Engineering and Biotechnology Abstracts**
- **National Technical Information Service**
- **Ei Compendex**
- **Pascal**
- **Tulsa World**
- **Chemical Abstracts**
- **MHIDAS – Major Hazards Data Incidents Service**

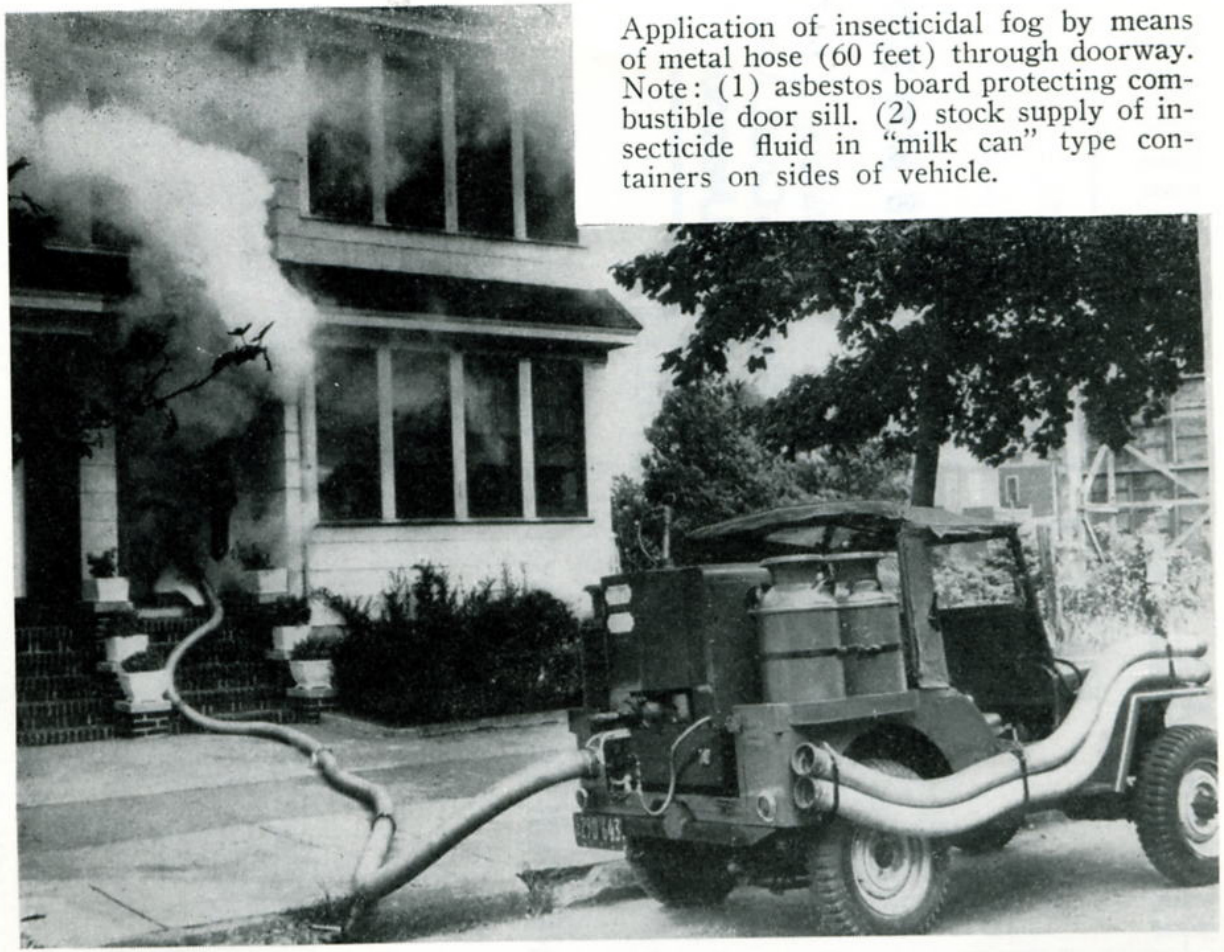
- **HSEline (based on the HSE's library catalogue)**
- **Nioshtic and Oshline from the National Institute for Occupational Safety and Health (NIOSH) in the US**
- **The Reyerson International Labour Occupational Safety and Health Index, from the Ontario Ministry of Labour**
- **Cisdoc, the database of the International Occupational Safety and Health Information Centre of the International Labour Organisation in Geneva.**

- 23 relevant records detailing 33 incidents have been identified. In some cases, the incidents may have been large fires or explosions. In all cases, the incidents arose from the ignition of mist, in most cases at a temperature near or below the liquid flash point.

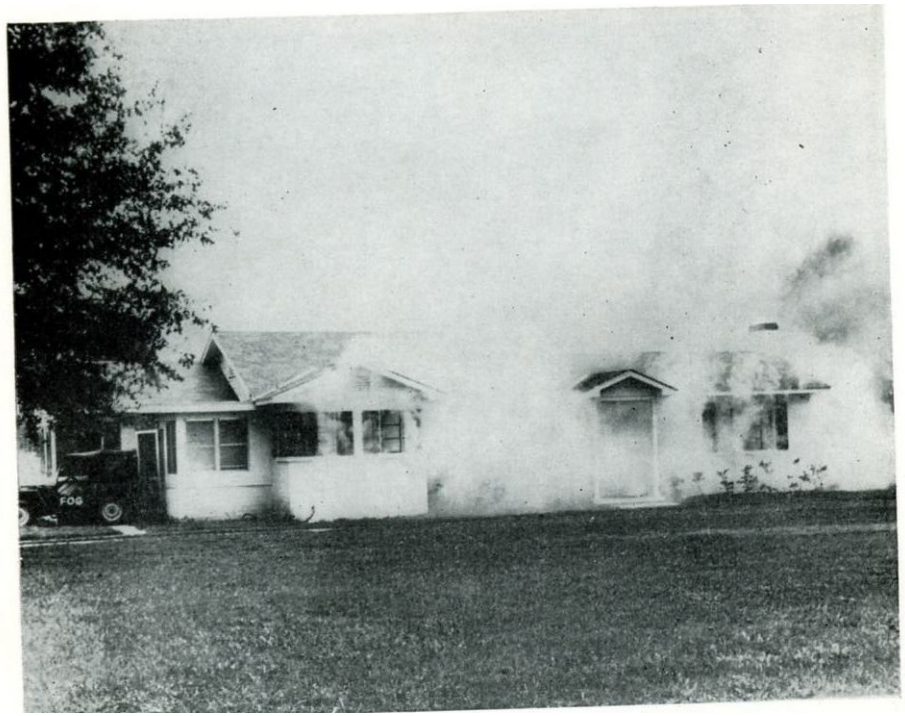
1. 1886, UK [2]

   An explosion in the cargo compartment of SS Petriana was the first serious explosion in an oil tanker. Mist of Russian kerosene (flash point 26 ºC) forced through a leaking seam was ignited by a naked light.

   10 fatalities.



Application of insecticidal fog by means of metal hose (60 feet) through doorway. Note: (1) asbestos board protecting combustible door sill. (2) stock supply of insecticide fluid in "milk can" type containers on sides of vehicle.


FOG

2. 1946-1952 USA [3]

Following the development of smoke screening techniques in the 2nd World War, the fumigation of buildings and outdoor areas using thermal aerosol generators became popular in USA using insecticides such as DDT and BHC suspended in hydrocarbon carriers. Indoor fogging machines were built to create a particle size of 0.5 to 10 microns. Their use led to explosions in which several people were injured and premises were destroyed. Guidance which includes descriptions of seven incidents was issued by the insurance industry. Kerosene, diesel and naphtha were listed as carriers in these cases. Pilot lights that had been left burning in domestic premises appear to have been the most common sources of ignition.

Several injuries.

3. 1959, USA [4]

   Centrifugal compressor test on recirculating loop. Lube oil mist explosion after 6 hours. Broken windows at 150 m. Source of ignition not determined. Probably compression autoignition?

   Six fatalities, 30 injured.

4. 1965 [5]

   A powerful explosion and ensuing fire occurred while gravity loading kerosene (flash point 110 – 130 ºC) to a barge under conditions producing excessive bubbling, foaming and turbulence. Explained as static ignition of mist.

5. 1973, Norway [6]

   Flash-over in 2 m^3 oil filled cable junction box in underground transformer room at hydroelectric power station. Box ruptured, oil expelled into 800 m^3 unvented cell, ignited by the arc in the junction box. Wall of concrete cell blown open.

   Three fatalities, several injured.

6.c. 1975 [7]

A road tanker was being splash filled with gas oil, flash point 65 ºC. Mist ignited, with sheet of flame 6 m high. Source of ignition probably static.

7. 1978, USA [8]

   During oil well drilling, the well blew out and oil was ejected. Mist created by the discharge ignited by overspeeding engines. Subsequent fire burnt for five days.

   Two injured, one fatal.

8.1980, USA [9]

Under-road pipeline ruptured. Naphtha (flash point 20 – 30 ºC) sprayed 20 feet into the air. Ignition source unknown. Explosion followed by fire.

Five injured.

9. 1980, Belgium [10]

   Piping leading to a pump failed at a thread, pressurized oil was sprayed and reached a steam pipe. Part of the pipe's insulation was damaged and a valve and strainer were bare. The temperature of the steam was 400 ºC and resulted in auto-ignition of the lubricating oil.

10. 1982 UK [11,12]

    Heated aviation kerosene, flash point 70 ºC, was sprayed onto the walls to clean a large empty black oil storage tank. The explosion demolished the tank. Source of ignition may have been floodlights, surface temperature 300 ºC, steam coil, or static.

    Three fatalities

11. 1984 Switzerland [13]

Rupture of a gasket in a crude oil line due to sudden pressure changes. Spraying oil ignited.

12. 1984, Salford, UK [14]

A passenger train carrying approximately 200 passengers ploughed into the rear of a tanker train. An explosion occurred immediately on impact, killing three people and seriously injuring seven others. The tanker train was carrying light gas oil (flash point 66 ºC). It is thought that the explosion and resulting fireball was caused by the ignition of oil mist produced by the collision, although other sources of ignition and fuel are suggested.

Three fatalities, 53 injured (Seven serious)

13. c. 1985-1995 [15,16]

Four incidents over ten years involving thermal oil systems released in the form of a mist are reported by Factory Mutual. Heater flame was probable source of ignition in one case. No details given for other incidents.

14. 1986, UK [17]

    Oil mist in a frying plant of the type used for snack foods exploded. Following an operational shutdown, mist had been drawn into a combustion chamber where there were burning residues.

    A similar incident occurred in 1992.

15. 1987, repeated 1989 [5]

Butyl acrylate (flash point 49 ºC) ignited in a properly grounded tank car at 15 ºC. High velocity feed. Two identical incidents. Both incidents explained as static ignition of mist.

Pratt *et al.*[18] in describing the first incident noted that the tanker had previously contained methyl methacrylate (flash point 13 ºC) and the vapour space had not been flushed. Generation of mist and static sources of ignition seem probable, but these were probably not true high flash point mist ignitions.

16. 1988 UK [11]

An aerosol of aviation fuel escaped during a test run because of a suspected blockage in a drainage system and ignited on the test rig igniter. No injuries were reported.

17. 1990 USA [19]

Pilot scale catalytic oxidation in an unspecified organic solvent under oxygen atmosphere exploded violently at a temperature below flash point. Mist generated by agitator was probably ignited by residual contaminant catalyst. Static, mechanical (friction) or cool flames also suspected.

18. 1992 [13]

A compression fitting failed during maintenance work releasing fuel oil as an aerosol at 450 psi and 70 ºC. The oil ignited and the plant was severely damaged.

One fatality, one serious burns

19. 1994, UK, Offshore [21]

    Small lube oil mist fire at gas turbine start-up

20. c. 1995, UK [20]

Maize oil collected on a filter cloth. Oil mist was produced when the cloth was cleaned with compressed air. The mist passed to an electrostatic precipitator and there was an explosion.

21. 1996, UK [11]

    A release of naphtha (flash point 20 – 30 ºC) from a loose connection in the fuel manifold at a large gas turbine formed a mist and ignited from the turbine surface. This was a marginal example of mist explosion. The release temperature was such that the cloud consisted of a mixture of liquid and vapour.

    One serious injury

22. 1997, UK, Offshore[25]

Diesel mist fire at gas turbine at fuel changeover, ignited from hot surface.

23. 1997, UK, Offshore [21]

    Small lube oil mist fire at gas turbine.

24. 1999 [22]

A 25 mm screwed nipple and valve blew off a heavy oil line operating at 350 ºC. Most of the plant was covered by an oil mist 30 m deep which was sucked into the control room by the ventilating equipment, making it difficult for the operators to shut down the plant. However, they managed to do so before the mist caught fire about 15 minutes later. There was extensive damage to the plant.

25. 2002, UK, Offshore [23]

Small lube oil mist fire at gas turbine during load test.

26. 2003, USA [24]

A shipyard welder was injured and died 62 days later from burns she sustained when sparks from her wire fed welder ignited atomized hydraulic oil which powered an elevating work platform. It was believed that a small pinhead leak developed in the lines while the victim was welding. This leak allowed the pressurized hydraulic oil at 120 bar to escape and atomize into the immediate work area.

One fatality

27. 2003, UK [25]

    A spraying bar at the back of a tanker was being cleaned with a kerosene/gas oil mixture and the mist ignited, allegedly static.

    Two injured, one fatally

- 9 incidents alone responsible for 29 fatalities

Fuels

Oils:	Lube oil	5 incidents
	Transformer oil	1
	Vegetable oil	3
	Hydraulic oil	1
	Fuel oils	7
	Crude oil	3
	Heat transfer oil	4
Kerosene		7
Naphtha		4
Butyl acrylate		2

Sources of Ignition

Compression autoignition	1
Electric arc	1
Hot surface	3
Static	6
Combustion chamber/igniter/pilot flame	10
Hot work	1
Engine induction	1
Catalyst	1
Naked light	1
Unknown	13

Conclusions

- Insufficient data for realistic use in QRA.
- The listed incidents are mostly in UK and USA, with a few in Europe. Whole world numbers will be higher.
- The listed incidents are mostly those that were significant and worthy of report. Whole world numbers including less significant incidents and near misses will be far higher.
- The number of reported incidents is far higher than had been known. The hazard is very real and must be taken into account in risk assessments and mitigation.

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