Explosion of a gasoline vapour cloud formed in a hydrocarbon loaded effluents storage tank

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Arquata Scrivia

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UVCE
Storage tank
Hydrocarbons
Steam coil
Corrosion
Steam
Instrumentation
Management

THE FACILITIES INVOLVED

The facility

The accident took place in a hydrocarbon tank farm, in 1999. The plant is under the condition of Safety Report presentation, due to the Italian decree implementing the “Seveso II” European directive.

The storage activities concern the reception, storage and distribution of liquid petroleum products and LPG by pipelines and tankcars. The storage capacities are the following:

- ✓ Gasoline: 200,000 t
- ✓ Diesel: 360,000 t
- ✓ LPG : 4,300 t

The unit involved

The accident happened in the plant unit where drain water from gasoline and gas-oil tanks is temporarily stored (water with some hydrocarbons).

The figure below describes the process and the different equipments. The drain water from the storage tanks is directly sent to a sump tank by gravity and from here pumped to the drain water tank. Before joining the process water and being fed to water treatment plant, the drain water is sent to an air stripper, in order to remove the MTBE (2-methoxy 2-methylpropane). The water treatment plant is intended to remove the oil content and to enable the water to be discharged in the sewing system. Before feeding the water treatment plant, the oily waters are sent to a settler and a water storage tank.

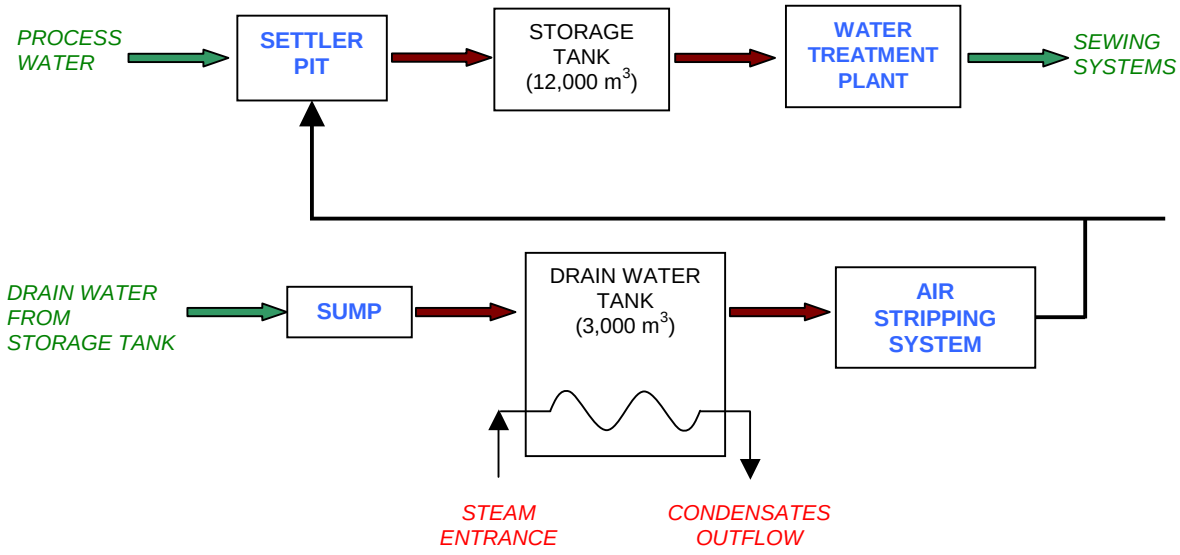
The following equipments were in operation in the storage plant when the accident took place: unleaded gasoline tank, sump tank, drain water tank, air stripping treatment plant, settling tank, water treatment feed tank, waste water treatment plant, sewing system.

The draining operation is performed manually by an operator. For this purpose, the following valves are open, in sequence:

- ✓ on the sump tank inlet pipe
- ✓ on the pump discharge
- ✓ on the pump suction

✓ on the outlet from the water pot at gasoline tank bottom.

Process diagram



The operation is stopped by closing this last valve when the operator can realize that gasoline is flowing to the sump tank, instead of water. A high level signal on the sump tank then starts automatically the relevant draw off pump, in order to let the water to be forwarded to the drain water tank.

The drain water tank is floating roof type, with the following geometrical characteristics: its maximum capacity is 3,000 m^3, its diameter is 16 m, it is 14,5 m-high and its maximum roof height is 12 m. The tank is not diked, being the surrounding area just soil and gravel, without any impermeabilization. The tank is equipped with an internal steam heating coil, positioned at the bottom.

A TV monitoring system is provided in order to watch over the actual height of the floating roof. This indication is reported in the control room. Two high level alarms are provided, set at 11 and 12 m (operational conditions) and two block systems are provided, set at 13 m, with automatic stop of the feeding pump.

Furthermore, the tank is provided with all the fire fighting equipment required for this type of tanks.

THE ACCIDENT, ITS CHRONOLOGY, EFFECTS AND CONSEQUENCES

The accident

At the moment of the accident, the liquid level in the drain water tank is 3.4 m high, corresponding to about 680 m^3 of hold-up. The amount of hydrocarbons contained is about 20 m^3, since it is estimated a depth of the upper layer about 10 cm. The drainage of the unleaded gasoline tank has been just started, by sending the drain water to the sump tank. At that moment, the wastewater treatment plant is not running continuously, as in normal operation.

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About 20 m^3 of hydrocarbons are released by the safety vent of the drain water tank on the floating roof and, from here, flow through the roof draining pipe to the ground. A pool of hydrocarbons is formed near the tank. A vapour cloud is formed by the hydrocarbons evaporating from the pools on the tank roof and on the ground, reaching the neighbouring road, located about 60 metres away.

The meteorological conditions are characterized by clear sky and absence of wind.

A UVCE occurs, due to the ignition of the cloud, probably caused by two lorries passing along the road.

The UVCE is followed by two other explosions, taking place after few seconds. The flashback flame ignites the hydrocarbon pools, with the engulfment of the drain water tank and the following involvement of the nearby settler.

Consequences of the accident

The damages to people have been limited: the drivers of the two lorries suffered light burns and recovered in 7 and 15 days.

The material consequences have been more significant, due to severe damages to the drain water tank and the settler, some minor damages to a nearby building and damages to the two lorries and another vehicle.

The economical consequences are estimated at 5 million euros, due to direct material damages, and 3.5 million euros, due to response, restoration and clean-up.

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The European scale of industrial accidents

By applying the rating rules of the 18 parameters of the scale made official in February 1994 by the Committee of Competent Authorities of the Member States which oversees the application of the 'SEVESO' directive, the accident can be characterised by the following 4 indices, based on the information available.

The parameters that comprise these indices and the corresponding rating method are available at http://www.aria.developpement-durable.gouv.fr

The level 1 of the index concerning the quantity of dangerous materials released (in the meaning of the SEVESO Directive) expresses the effects of the explosion (parameter Q2) that led to 10% broken windows within 330 m radius. This corresponds to 100 kg equivalent TNT.

The level 3 given to the human and social consequences is due to the two lorry drivers who have been injured (paramater H4).

There is no noticeable environmental consequence.

The level 3 given to the economic consequences is due to the € 5M material damages inside the company and € 3.5M response, restoration and clean-up expenses (parameters € 15 and € 18).

THE ORIGIN, CAUSES AND CIRCUMSTANCES SURROUNDING THE ACCIDENT

The tank is equipped with an internal steam heating coil, positioned at the bottom of the tank, in order to keep the temperature at 20-30℃ for winterizing and for a sl ight preheating, to improve the following air stripping, which is the next step of the process.

The day of the accident, live steam entered in the tank, due to a failure of the coil, probably caused by corrosion. The inner temperature of the tank rose up to 60°C at le ast, causing the evaporation of lighter hydrocarbons content to start. The filling with condensed steam and the internal overpressure caused the opening of the safety vent on the floating roof with an outflow of the upper hydrocarbon layer on the top of the roof.

ACTIONS TAKEN

The internal emergency plan has been immediately started. An emergency shutdown of the plant has been carried out and the fixed firewater cooling systems activated. The fire fighting has been carried out in the initial phase by the internal emergency team. In the meanwhile, the alarm has been given to fire brigades, first aid and police.

In 15 minutes the external intervention was carried out by:

- ✓ Fire brigades starting to fight the fire (extinguished after one hour and a half)
- ✓ Police controlling the local traffic, blocking the nearby road and coordinating the precautional evacuation of houses and workshops nearby the place of the accident
- ✓ Ambulances arrived for first aid and transfer of injured people to the hospital.

LESSONS LEARNT

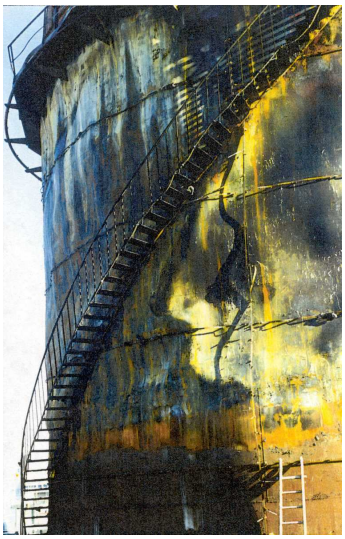
The lessons to be learnt from this accident are leading rather to managerial features, than to physical and more direct causes. The identification of the first ones enables to define concrete actions to carry out in order to prevent durably this kind of accident.

For this reason and consistently with the principles stated in “Seveso II”, a specific approach has been developed and applied in Italy to perform the analysis of accidents with the main scope to point out the faults in the Safety Management System (SMS), directly connected to the accident itself or anyhow shown by the events and circumstances related to the accident.

Reference is made to the check list of the SMS elements considered, consistent with the main articulation given for the SMS by the “Seveso II” directive.

On the basis of this accident, the lessons that could be learnt and worth being highlighted are:

- ✓ An exhaustive, and detailed risk analysis must be realised, taking the accidentology into account.
- ✓ The instrumentation to indicate parameters (temperature, thickness of the hydrocarbon layer) must be sufficient and fitted to the identified risks in order to detect anomalies and/or dangerous situations.
- ✓ Safety barriers must be enslaved to the detectors provided (temperature, level, pressure, etc.) in order to prevent any runaway or accident.
- ✓ Periodic inspection and the eventual repair or substitution of the steam coil (potentially affected by corrosion) must be taken into account in the maintenance procedures.
- ✓ During the realization of technical-plant modifications on a tank (coil installation), it must be taken into account:
  - ✓ Spotting of dangers and the evaluation of relevant accident risks;
  - ✓ Verify the compliance with safety requirements and criteria;
  - ✓ Final validation of design modifications.
- ✓ Safety audit aimed to evaluation of conformity to regulations of SMS and of its efficiency should have put on evidence the above-mentioned management faults.



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