Tank failure in a bitumen storage unit of a refinery

8 September, 2004

Italy

Refinery
Storage unit
Tank
Bitumen / hot-oil
Failure
Overpressure
Victims

THE INSTALLATIONS IN QUESTION

The site:

The refinery is located in the centre part of Italy, and is strategically situated in the middle of the Adriatic coast to cover a large area of eastern Italy. it is part of one of the top 20 private industrial groups in Italy.
It has been operating since 1950, and has about 500 employees. It has a production capacity of 3.9 million tons/year, and represents nearly 5 % of national refining capacity. Its storage capacity is over 1.500.000 m3 of oil products in 128 tanks.
The plant, cover 70 ha of area, and is located in an urban site (Fig. 1), near the city, the motorway, the railways, the port (slipway) and the airport.
The plant is under Seveso II Directive (upper tier plant).

Fig. 1 Photo DR

The unit concerned:

The unit consists 12 fixed roof tanks, 8 loading arms and 6 pumps for transfer/loading of bitumen, 1 heat-exchange for possible additional heating of stored bitumens.

The accident took place in the cylindrical atmospheric tank of bitumen (TK145), operative since 1970 and extended in the near loading/unloading areas. With 1200 m^3 of capacity, 12 m of height, the tank was equipped with an internal heating coil, positioned at the bottom, in order to assure an internal temperature of 170℃. The coil was feed with hot-oil at 280℃.It was also equipped with level indicator, temperature indicator, and a mixing stirrer.

There were about 592 m^3 of bitumen inside the tank, and about 150 m^3 of hot-oil inside the heating circuit, at the moment of the accident.

THE ACCIDENT, ITS BEHAVIOUR, EFFECTS AND CONSEQUENCES

The accident:

At 07.25 a.m., a catastrophic tank (TK145) failure occurred: the shell and roof tore off the foundation were projected in vertical direction, and were moved laterally 15 m away. Along the way, they broke some pipe rack, at about 5 m of height, and then fell and on a 2nd bitumen storage tank, causing a massive total leakage of bitumen (about 550 t) and hot-oil (about 120 t) at 170°C, and their spreadin g all over the areas.

The missile-tank exploded fell down on a 2nd bitumen tank (TK166) of 8000l of capacity. The missile roof entered in the TK166 shell, then squeezed itself into the TK166 basin (Fig. 2,3).

A pool-fire was then ignited in the TK145 basin, other fires followed involving equipments in sight, with domino effect on others tanks and on some tank-trucks under loading, located in the area. The fire was then fed by the hot-oil releasing from the heating circuit, due to the tear of the circuit lines connected to the tank coil.

At the moment of the accident, there were 8 tanker in the area, ready to loading/unloading operations and 9 persons in the site: 7 drivers, one internal shift operator and the site-head which is inside the building located in the area, and had just finished the line preparation for tanker n°1 l oading from the TK145. The operator was monitoring the TK252 level, installed on the basin wall in common with the other bitumen storage tanks (TK251, TK252, TK253 e TK328).

The emergency alarm started and the internal emergency measure, cooling and spread-foam systems activation, were immediately applied. The internal fire team's intervention was immediate, involving 6 fire-men and 2 fire-trucks.

After 25 minutes from the internal emergency alarm, the external Fire Brigades arrived. All the units area involved was put in safety condition.

After about 3 hour the fire was controlled, and the emergency was closed.

The consequences:

The accident caused effects to people and to environment, and did non lead to significant off-site consequences, even if the accident generated distress in the population, which was taken into account by the media and the public authorities.

Human effects

One driver burned by bitumen and projected inside a tank basin, where his body was found 3h later the fire extinguished. Three other drivers differently injured by the contact with the hot bitumen: 2 hospitalised and 1 treated and released.

Environmental effects

The bitumen released expanded in a vast area of about 13.000 m^2 (2% whole refinery area). Part of the product (6-34 t) involved the external site, releasing in the sea through an internal ditch of the refinery.

The effects of the smoke plum on the near city population were judged at low impact by the Regional Agency for the protection pf Environment.

Consequent to the accident, the central scientific research institute for the sea performed a series of controls in the sea, and recovery operations of spread bitumen. Moreover, sanitary local authorities conducted some shellfishes analysis.

Limited quantities (some hundred of kg) of bitumen were recovered in the sea near the establishment, or in the seaside beach for 8 km far away.

Economic consequences

According to a preliminary costs estimation made by the society:

-3 millions of euros for structural losses

-0.5 millions of euros for emergency

-3 millions of euros for clean up

-31 millions of euros for response and restoration of the establishment

-25 millions of euros for production loss (for 1 year, which is the time estimated for the bitumen plant activity recovery)

Fig. 2 Photo DR

Fig. 3 Photo DR

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 the following address: http://www.aria.ecologie.gouv.fr.

About 120 tons of hot-oil (classified as dangerous for the environment R51/53) have been involved (5% of 500 tons Seveso threshold) justified the level 3 for "dangerous materials released" (parameter Q1).

With one person death and three other injured, the parameter "human and social consequences" reached the level 2 (parameter H3).

The level 3 for "Environmental consequences" is explained by the pollution of the seaside beach for 8 km far away (parameter Env14).

The production losses, estimated at 25 M€, explain the level 4 for the "economic consequences" (parameter €16).

ORIGIN, CAUSES AND CIRCUMSTANCES OF THE ACCIDENT

The two principal hypotheses assumed based on a preliminary analysis conducted by the society, are:

- an internal overpressure in the tank caused by explosion of light flammable hydrocarbons, wrongly introduced in the tank

- an internal overpressure in the tank caused by rapid phase transition of water, wrongly introduced in the tank, (internal temperature 170°C)

Further following investigations lead to consider the first one, related to the wrong introduction of light flammable hydrocarbons compounds during unloading to the tank of bitumen in excess present in tank-trucks.

ACTIONS TAKEN

Emergency measures:

Internal fire-team immediately was activated, followed 30 minutes later, by Fire Brigades (15 trucks and 35 fireman).

The external emergency plan was activated with:
- interruption of railways traffic, which runs inside the plant
- interruption of the near roads traffic
- reduction of the near airport activity, without practical consequences
- blockage of electrical feeding of 132 kW line which runs along the railways
- start-up of the mixed advanced coordination centre
- start-up of the procedure for the information to population.

Fire was handled through water and foam, while tanks and browsers involved were been cooled (Fig. 4, 5, 6).

After about 2 hours the fire was under control, and the railways traffic was opened 3 hours later.

The emergency was concluded with the put in safety of the plant, according to the dispositions of the judicial authority, who sequestrated the whole area.

Fig. 4 Photo DR

Fig. 5 Photo DR

Fig. 6 Photo DR

Actions taken:

A detailed investigation is still in course, to understand the causes of the accident.

The regional technical committee immediately disposed to the operator after the accident:

- detailed technical report of the accident, containing the design solutions adopted in similar bitumen plants
- request of a new SMS inspection
- adoption in short/medium period of the following measures acted to move the loading ramp away from the storage area and verify the safety conditions of all the hot-oil circuit of the refinery
- improve the internal emergency plan, in particular the time to evacuate operators, and the interface between internal and external fire-teams.

LESSONS LEARNT

The accident put in evidence some SMS issues that had an important role in the event occurred. The table here below explains, for each SMS issue identified, the principal corrective actions taken or planned.

Description	Actions taken	Actions planned
Operating procedures and instructions in normal, abnormal and emergency conditions	More attention for process parameters monitoring, providing a temperature controller of bitumen inside, and blockage in case of over temperature max. The same for temperature and flow of hot-oil in the coil.	Realization of temperature control systems for bitumen in the tanks, with heating system blockage and bitumen feeding blockage Realization of blockage system of hot-oil line to tank coils, in case of over temperature Realization of blockage system of hot-oil flow-rate, in case of different flow-rates in input/output from plants
Emergency team organization. Alarm systems and communication and support to the external intervention	Difficult communication among fire teams. Need of a more rapid recognition of possible persons missing. Need of an improvement in information exchange between the emergency centre (in the offices) and the operators in site. Need of a more integration between the internal fire team and the Fire Fighting	Internal emergency plan improvement, in particular for the involved personnel control and census, and for the operative emergency procedure of internal fire team
Controls and verifications of the management of emergency situations	2 bitumen tanks involved didn't have the cooling system active	
Identification of substances and processes hazards; definition of safety requirements and criteria. Emergency management	Plant lay-out, storage area too close to loading area, few space available for emergency team intervention….	Remove the loading platforms from the storage area
Planning and updating of technical and/or managerial solutions for the reduction of risks	Need of a more congruency between safety analysis, operative procedures on normal, abnormal and emergency conditions, and actions for risk reduction. The safety analysis should consider a possible introduction of lights compounds by unloading the bitumen from the overloaded tank-truck	realization of automatic system for tank-truck loading, equipped with weigh at prefixed load, too-full detectors and systems "at present man", to avoid or limit overloading prohibition of direct unloading of overloads to bitumen tanks adoption of management and technical measures to avoid water and lights introduction in bitumen tanks provide an explosive atmosphere presence monitoring inside the bitumen tanks
Maintenance procedures	Necessity of systematic control of restoring and washing for the tank-trucks	Adoption of system to verify the presence of the recovery and clean-up certificates for the tank-trucks