Explosion
Fire
Domino effets
Refinery
Catalytic cracking
Column
Material failure
Valve

Explosion in a cracking unit on a refinery site.

September, the 3rd , 2000

Gonfreville l'Orcher [Seine Maritime] France

THE INSTALLATIONS IN QUESTION

The site:

The refinery is located in the industrial port zone of Le Havre, in the district of Gonfreville l'Orcher and Rogerville. The unit in which the accident of September 3rd, 2001 occurred is known as "cracker no. 7", and is a catalytic reforming unit that produces high-octane gasoline fractions. The unit can treat up to 4,200 t per day of product, following the successive phases described below:

1 – Desulfurization-hydroprocessing Section:

The load is mixed upstream of the heating and hydrogen reaction section. Following the reaction, the various reaction products (water, H2S, gas etc.) are separated and the gases are condensed.

2 – Catalytic reforming Section:

The catalytic reforming operation is designed to transform normal paraffins and naphthenes into aromatics, allowing the production of high-octane gasoline fractions.
The reaction is performed at a high temperature (~500°C) and at a pressure of around 14 to 20 bar. It is an endothermic reaction and produces a fluxing medium that is rich in hydrogen and is used, in particular, in the xylene isomerization section.

3 – Fractionation Section:

This section comprises the separation of the different fractions formed during the catalytic reforming reaction. The reformate separated from the light fractions is sent to storage, with a view to the preparation of fuels by mixing.

On an administrative level, the unit was initially authorised by a prefectorial order dated November 30th, 1967, and was made subject to complementary provisions on March 12th, 1997, following a danger study.

THE ACCIDENT, ITS BEHAVIOUR AND CONSEQUENCES

The accident

A fire with muted explosions broke out at the refinery in Gonfreville l'Orcher on September 3rd, 2001, around 9.15 p.m., on the desulfurization section of the cracker 7 unit. The fire burned actively until 3.15.p.m. on September 4th. The chronology of the accident is as follows:

9.12 p.m.: rupture of a ¾ inch connection on the suction line of pump P3B,

9.12 and 30 seconds p.m.: flash-up of the cloud (approximately 200kg of product) and creation of a fed torch-type fire,

Source : Presse Paris Normandie

9.13 p.m.: rupture of a 3 inch naphta line that was exposed to the torch, which created another, larger flaming jet,

9.18 p.m.: through a domino effect, rupture of the manifold of a cooling tower and flash-up of the leak that was caused,

9 22p.m.:

- through a domino effect, rupture of the header (8 inch diameter) of tube V3, and flash-up of the leak,
- through a domino effect, rupture of the valve manifold of tube V3, which is connected to the site's flare-stack network, and flash-up of the gas leak. This led to a partial venting of the flare-stack network.

From 10 p.m. onwards: the burning leaks continued to burn until the rest of the unit was consumed and the flare-stack network could be isolated without danger, which was on September 4th, around 3 12 p.m.

Combating of the emergency:

The emergency was combated by means of the refinery's fire-fighting equipment and the firemen of Le Havre.

The strategy for fighting the fire consisted in limiting the dangers of the fire spreading and cooling the superstructures that were exposed to heat fluxes, in order to prevent collapse. However, at the height of the fire, extremely high flow rates of water were used (in the order of 2300 m^3/h, at 7 to 8 bar, taken from the site's fire system).

Consequences:

Two firefighters from the refinery were slightly injured, effected by the heat during the intervention.

The fire had no significant impact on the environment, and the fire protection water was stored in a 60,000 m^3 buffer storage tank designed for that purpose.

Following the accident, the unit was shutdown for around 7 months. The amount of the damage is in the order of 14 M€ for rehabilitation and 68 M€ in operating losses.

European scale for industrial accidents

By using the rules for quoting the 18 parameters on the scale formalised in February 1994 by the Committee of Competent Authorities of the member states for the application of the 'SEVESO' directive, the accident can be characterised by the 4 following indices, taking into account the available information..

The parameters of which these indices are composed and the methods of quotation are available at the following address: www.aria.ecologie.gouv.fr.

The level 1 rating attributed to the "dangers materials released" index reflects the explosions that occurred during the accident and which were limited to the unit involved (parameter Q2).

The 2 firemen from the site who were injured during the intervention explains the level 1 rating of the "human and social consequences" index (parameter H5).

The level 5 rating attributed to the economic consequences rating reflects the extensive property damage (14 M€) and operating losses (68 M€) generated by the accident (parameter €16).

ORIGIN, CAUSES AND CIRCUMSTANCES OF THE ACCIDENT

The accident originated at the level of a pump and steam turbine unit (reference no. P3B). In fact, the accident was provoked during a phase of periodic testing of the equipment, which is in fact a backup unit of pump P3A.

The various analyses carried out following the accident allowed the identification of several factors that together provoked the accident:

- ✓ The presence of condensates in the turbine (discharge valve closed),
- ✓ Faulty fixing of the frame to the base,
- ✓ Insufficient lubrication of the pump bearing,
- ✓ Pump design with an overhung rotor,
- ✓ Cavitation phenomena on the pump, due to insufficient suction.

This led to:

- strong vibrations on the pump, which caused the rupture of a ¾ inch connection located just above the pump, through fatigue stressing,
- a misalignment of the turbine/pump, which caused a rupture of the shaft and deterioration of the connection.

An aggravating event has been identified: the abnormal delay in closing the supply line's shut-off valve on pump P3B (approximately 10 min). Indeed, if the closing of this valve, which was ordered by the programmable safety controller had been carried out within the time anticipated (approximately one minute), the domino effects on the other piping could have been prevented and the gravity of the accident would have been vastly reduced.

ACTION TAKEN

Following the accident, an emergency measures order was signed on September 4th, 2000, requiring the operator to provide:

- ✓ A list of the installations affected by the accident,
- ✓ A report of the accident and details of the measures designed to prevent the re-occurrence of such an accident,
- ✓ A report concerning the operating condition of the equipment.

The order also specified that the restart of the installations was subject to preliminary authorisation from the prefect.

The emergency measures order gave rise to several exchanges of communication with the operator. In particular, two letters were sent by the DRIRE (Direction Régionale de l'Industrie, de la Recherche et de l' Environnement), the regional board of industry, research and the environment, to the operator on October 6th, 2000. These two letters were requests for:

- ✓ Recourse to a third-party expert who would examine the accident report drawn up by the operator,
- ✓ Implementation of a systematic, methodical inspection plan to assess the condition of the equipment.

Following examination of the neighbouring equipment, the operator advised the Prefect that only the "cracker no. 7" unit was considerably affected.

Condition of the equipment:

As regards this point, the following method was decided upon:

① In the first instance, an inspection plan (methodical and systematic) was established. The plan was approved by an expert also used by the insurance companies.

② The inspection plan was implemented for the totality of the equipment which could have been affected by the accident.

③ Implementation of the inspection plan allowed classification of the equipment according to its serviceability (category A, B or C).

Taking these factors into account, the DRIRE notified, by mail, the respective classifications given to each piece of equipment as a result of implementation of the inspection plan, and also sent a reminder that the various construction and repair operations to be performed on the equipment should be carried out in accordance with recognised trade practices and the strict adherence to the regulations concerning the matter.

Corrective and preventive measures:

The operator proposed the following corrective measures:

✓ Modification of the type of pump and the vertical positioning of the tube, to prevent cavitation phenomena.

✓ Replacement of the motorised suction valves of pumps P3A and B, in order to obtain a quicker closing time, with the objective retained by the operator being closure in less than 30 seconds.

✓ Modification of the speed regulation device of the turbine, in order to obtain an "isochronous" governor,

✓ Replacement of the ¾ inch connections of the pumps concerned by 1 inch connections fitted with reinforcement gussets.

✓ Modification of the purge system of the turbines concerned,

✓ Implementation of an awareness campaign concerning the strict application of the operating procedures for turbines in the process of heating.

These recommendations were approved by the third expert, who drew up some supplementary regulations in parallel.

In the light of these different expert reports, the Prefect authorised the restart of the unit, on the condition that the operator respect the complementary provisions (complementary order dated March 27, 2001).

LESSONS LEARNED

As is generally the case, this accident is a clear illustration of how the simultaneous occurrence of several causal events which, if taken separately, can appear of secondary importance, and can have extremely serious consequences. The difficulty in the closing of the supply line's shut-off valve is also a perfect illustration of the theme of the aggravating factor.

This accident also reminds us that in the case of this type of activity, given the rapid development of the incident, everything hangs on the first few minutes following the occurrence of the accident.

As a result of the expert report ordered by the operator, the chronology of the accident was able to be reconstituted. This chronology was confirmed by the analysis performed by the third expert. However, in the context of its analysis, the third expert confirmed the great difficulty in treating the theme of the domino effects between units on this type of petrol installation. This observation is of concern as regards the revision of danger studies.

Lastly, it is important to remember that this accident could have had serious consequences in terms of human life if one or more operators had been located at the site where the leak occurred.