Explosion of a superheater within a steam-cracking unit

15 July 2009

Saint-Avold (Moselle)

France

Petrochemical industry
Gas explosion
Ignition/start-up
Instructions
Automatism/regulation

THE FACILITIES INVOLVED

The site :

The installation, located in Saint-Avold (France's Moselle Department), had been incorporated into an extensive industrial platform spanning over 340 hectares. The site was initially created in 1954 to combine a variety of activities related to the chemical and petrochemical sectors (see Fig. 1). The petrochemical operations at this facility were developed during the 1960's, with the 1969 start-up of a first steam cracker along with a polyethylene manufacturing plant a key moment in the life of this facility.

Using naphtha (light petroleum distillate) as the input material, the site manufactured basic petrochemical products (ethylene, propylene, methane), which then served as raw materials for the site's production of plastics (polyethylene, polystyrene).

This facility incorporated many installations that required special easement approvals ; it had been classified as an upper-tier "SEVESO" site due to the quantities of inflammable and/or toxic substances manufactured and handled.

Fig. 1: Exterior view of the site (RR)

The specific unit involved :

The steam cracker occupied the heart of the site. A light petroleum distillate, of the naphtha type, would undergo a cracking reaction at high temperature in the presence of water vapour in order to fragment the molecules into even lighter compounds.

This facility comprised many pieces of equipment and machinery, including two superheaters (Fig. 2). Their role was to increase the temperature of vapour produced in the cracking furnaces so as to eliminate water droplets, through the use of 7 burners fed by a fuel oil-gas mix. This overheated vapour then served as the driving force behind the main cracked gas compressor (Fig. 3).

Fig. 2: View of the unit's two superheaters (RR)

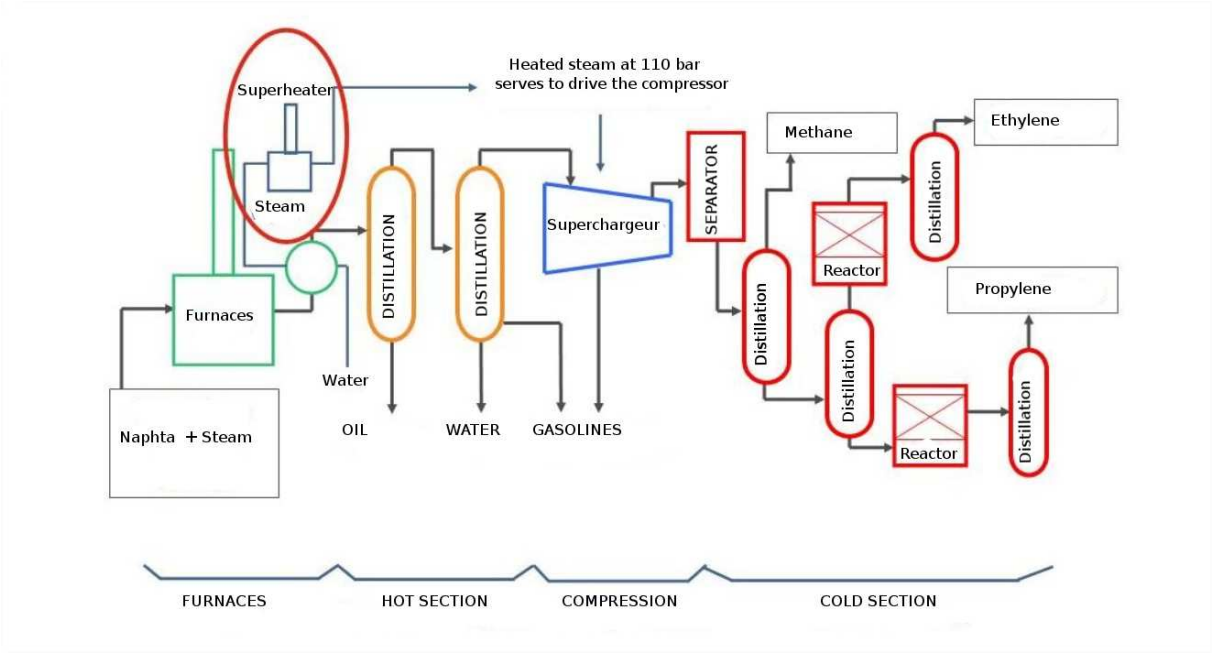


Fig. 3: Operating diagram of the steam cracker unit

THE ACCIDENT, ITS CHRONOLOGY, EFFECTS AND CONSEQUENCES

The accident :

Subsequent to a series of violent atmospheric precipitations during the night of 13 July 2009 to 14, combined with water infiltration causing damage to a utility room and disturbing the digital command and control system (damaged electronic cards), the steam-cracking line was shut down and placed in safety mode.

The line restart procedure was initiated on the morning of 14 July. On 15 July, the superheater was reset around 3 pm with the intention of manually lighting the burners. A technician, holding a mobile pole, took a position underneath the floor plate in order to light the pilot burners when the superheater exploded.

Consequences of this accident :

A total of eight victims were reported onsite :

- 2 deaths (both company employees), found below the superheater floor plate due to its collapse ;
- 4 injured (2 company personnel + 2 temporary workers), with second-degree burns ;
- 2 subcontracted employees at the scene, who were indirectly hurt (both sustained shock).

Property damage was confined to the superheater and its immediate vicinity (Fig. 4).

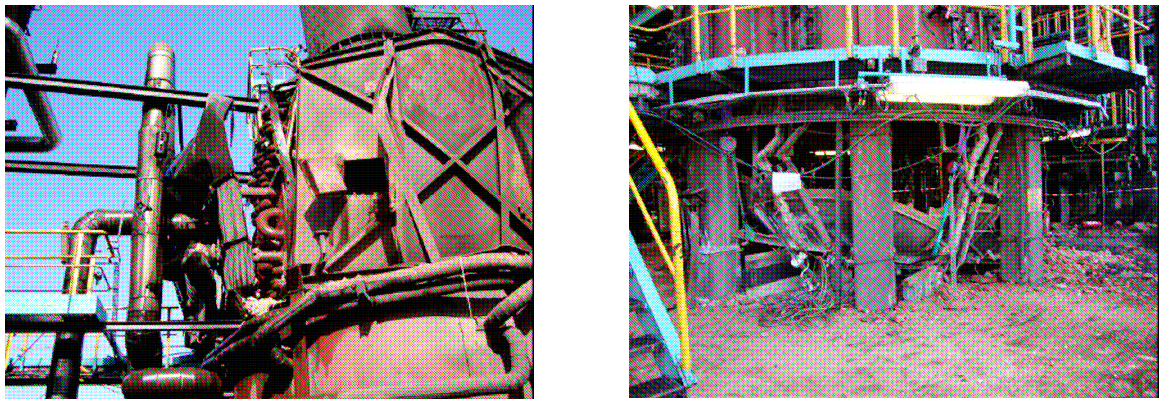


Figure 4 : View of damage sustained on the upper part of the superheater and collapse of the floor plate (DREAL Lorraine)

This explosion did not however produce any consequences outside the site and moreover in no way compromised the interests addressed in Article L. 511-1 of the French Environmental Code, namely :

- on environmental and health-related conditions, no exterior impact beyond the noise directly due to the blast, as well as the emission of a very short-lasting dust cloud resulting from the projection of refractory material, could be observed. The exploded superheater did not contain any toxic products (given its design as a steam superheater) ; moreover, the explosion was not followed by a fire.
- from the standpoint of accidental risks to third parties and given the amount of property damage, the pressure surge impacts were confined to the superheater's immediate vicinity. Broken glass was observed on the windows of a number of vehicles parked at an onsite lot some 50 metres across from the exploded superheater. This broken glass was most likely caused by either spewing refractory bricks that had lined the inside of the superheater or the excess pressure wave. Refractory debris and fragments, some reaching 50 cm in size, were found around the installation and up to 100 metres away. No risk however was generated in the form of a domino effect at other site installations.

The European scale of industrial accidents

By applying the rating rules applicable to the 18 parameters of the scale officially adopted in February 1994 by the Member States' Competent Authority Committee for implementing the '*SEVESO*' directive on handling hazardous substances, and in light of information available, this accident can be characterised by the four following indices:

The parameters composing these indices and their corresponding rating protocol are available from the following Website : http://www.aria.developpement-durable.gouv.fr

The "Hazardous Materials Released" index only received a "1" rating due to the small quantity of explosives involved (i.e. the quantity of natural gas < 0.1 tonne).

The "Human and Social Consequences" index was rated a "3" due to the deaths of 2 technicians and injuries sustained by 6 others.

The "Environmental Consequences" index was not rated given the absence of any impacts on the environment.

The "Economic Consequences" index scored a "4", based on the total destruction of a superheater, coupled with significant production losses resulting from the imposed 8-month plant shutdown.

THE ORIGIN, CAUSES AND CIRCUMSTANCES SURROUNDING THE ACCIDENT

At the time of this accident, the steam-cracking line had been undergoing a restart phase subsequent to a number of foul weather incidents that had occurred the day prior (during the night from July 13th to 14th, 2009). The procedure mandated was relatively long, with the start-up sequence being conducted section by section. The superheater was in the ignition phase when the explosion occurred.

According to the site operator, this accident resulted from the simultaneous occurrence of two factors :

- an accumulation of inflammable gas, yet within the flammability limit: the operator's investigation pointed to the hypothesis of a gas flow surge in the direction of a burner during the start-up phase as the ignition step was being carried out ;
- ignition of the cloud by either the tube ignitor or a hot spot inside the superheater convection zone. Other ignition sources could also be envisaged (e.g. electric spark, static electricity), yet these two cited sources would seem the most plausible.

A number of elements favoured the onset of this accident, whose serious consequences were tied to the presence of personnel in the vicinity of the superheater during manual ignition :

- failure to steam-sweep the superheater prior to its re-ignition, as stipulated in the operating procedure issued by the plant management ;
- gas input via a burner, despite the flame on the associated pilot being extinguished ;
- the technical safety system, which prevented supplying burners with gas in the absence of a pilot flame, was not operational. This system was composed of an automated mechanism that closed the gas supply valves in the event the flame detector was not triggered following a 10-second time delay. This mechanism would have been by passed due to its perceived lack of reliability within the specific environment of this superheater. Such a reliability loss could have caused the superheaters to behave erratically and led to repeated shutdowns/start-ups of the

steam cracker, hence a greater number of transient phases (keep in mind that a steam cracker shutdown remains exceptional, since it is normally operating continuously).

ACTIONS TAKEN

Government inspectors for industrial facilities arrived on the scene within a few hours after the accident. Subsequent to the observations recorded, a number of emergency measures were imposed upon the operator by the local Government authority. These measures were intended to make start-up of steam-cracking line installations contingent upon :

- submission of the accident report on the superheater explosion ;
- release of the safety report update specific to this part of the steam cracker ;
- presentation by a certified body of a set of elements proving the good working order of all plant equipment either directly or indirectly affected by this accident.

The facility was also placed on notice over failure to comply with a number of specifications laid out in the Gov. authority decree regulating operations of the facility's steam-cracking line, namely :

- performing a steam sweep prior to reigniting the superheater ;
- measuring flammability prior to restarting the superheater ;
- implementing a safety feature that activates in the event of pilot flame extinction on superheater burners.

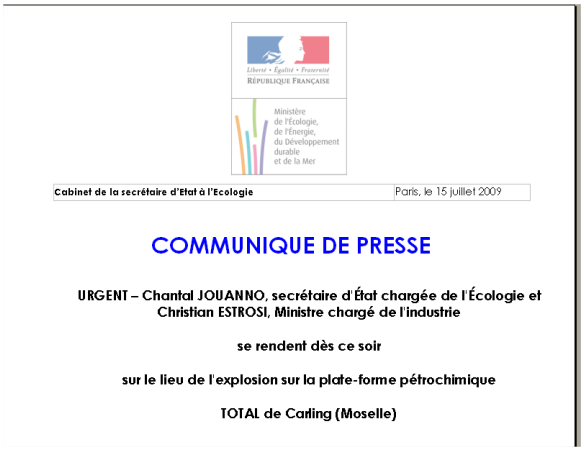
LESSONS LEARNT

This accident led the site operator to completely modify the ignition sequence of a superheater in order to limit the risk of repeating such an accident, in terms of both probability of occurrence and consequences; these efforts consisted of :

- introducing a programmable and servo-controlled automaton requiring all start-up stages to be performed, namely :
    - o steam sweeping ;
    - o pilot ignition ;
    - o burner ignition.
- setting up a control chart that comprises, among other things, the pilot lighting sequence and the procedure for remote-controlled valves. This measure made it possible for personnel to initiate the superheater ignition sequence remotely, thus limiting their exposure in the event of explosion.

This accident also provided the opportunity for an effective round of collaboration between the teams responsible for site inspection and the team supervising pressurised equipment, even though this factor was quickly eliminated as a potential accident cause. The ensuing collaboration served to streamline information exchanges and raise the calibre of corresponding analyses. Similarly, close collaboration was quickly established between labour inspectors and the classified facilities team.

As a final point, despite an event qualified as a "workplace accident" with no impacts felt outside the facility, management of this accident and its consequences heavily mobilised local teams of the French environmental administration. Media coverage, along with the assigned judicial investigation, also contributed significantly (Fig. 5).



Cabinet de la secrétaire d'Etat à l'Ecologie — Paris, le 15 juillet 2009

COMMUNIQUE DE PRESSE

URGENT – Chantal JOUANNO, secrétaire d'État chargée de l'Écologie et Christian ESTROSI, Ministre chargé de l'industrie

se rendent dès ce soir

sur le lieu de l'explosion sur la plate-forme pétrochimique

TOTAL de Carling (Moselle)

Figure 5 : Press release on the site visit by a delegation of Cabinet members following the accident