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TITLE OF THE PAPER : COMBUSTION PHENOMENA IN AN EMULSION WORKSHOP

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1. INTRODUCTION

EPC-France has a factory located in South of France, 60km North North-West from Marseille. The main activities are:

- Civil explosives production
- Civil explosives storage

The main products manufactured are:

1. Emulsion explosives cartridges
2. Anfo in 25kg bags
3. Bulk emulsion matrix

16000 to 18 000 Tons are produced every year. Employees' total number is 60.

425 Tons are allowed to be stored on site in 12 magazines.

The factory has been established and has produced civil explosives since 1893.

The plant surface area is about 350ha.

EPC-France started to produce Emulsion explosives cartridges since 1994.

Emulsion is a mixture with chemical oxidizing products and combustibles hereinafter referred to as "matrix". After mixing, a step of sensitizing with gassing agent in a reactor is necessary to produce explosives just before the cartridging machine. An operating temperature of 90°C ensures a high quality emulsion.

The EPC-France process requires maintaining a 90°C temperature to ensure good mixing and low viscosity for ease of matrix transfer in the pipe, with a minimum of pressure.

The cartridges are formed on a KP machine (Chub) and are cooled through a cold water bath. The emulsion structure is thus fixed with a homogeneous dispersion of very fine gas bubbles. After quality control, the emulsion explosives cartridges are packed in boxes to be delivered to the customers.

Electrical tracing technology was chosen by EPC-France for maintaining process temperature.

Different types of electrical tracing exist: autoregular and monitored by thermocouple.

EPC-France used the both technologies to meet different needs.

2. FACTS :

The accident occurred Saturday, the 11th November 2011, in the cartridging building of emulsion production line.

The incident started when the production was stopped due to a Bank holiday on Thursday, the 10th November 2011, 4.00 am. Nothing had been noticed up to the restarting of the production line on Monday, the 14th November in the morning.

The incident didn't affect the restarting of the production line. After about one hour of production, due to an odd smell, the decision was taken to stop production to investigate. Apart from the smell, there was no apparent evidence of an incident.

Operators decided to disassemble pipe and sensitization reactor to reassure themselves.

They discovered some of burn parts: inside the sensitization reactor, inside the pipe and the electrical trace around the pipe.

The machine is fed by a pump. The emulsion is pumped through a 50 mm stainless steel pipe from the emulsion blend hopper to the emulsion sensitisation reactor located on the top of the Chub machine. It is a metallic pipe insulated and electrically traced from the hopper up to the emulsion sensitisation reactor.

After each production, the pipe was cleaned with steam and the emulsion layer on the internal surface of the tube should have been cleaned off.

The inside of the workshop, was recorded 24/24 7/7 by camera fixed on KP machine.

On the video tape recording the following steps were evident:

- Friday, the 11th November **at 5:42 pm**. The combustion phenomena started 22 hours after the end of production.
- Some smoke had been produced without any flames.
- This combustion stopped the same day at **6:25 pm.**
- At this time, nobody was in the factory which was shut down and no material damage occurred in the facility.

The material damage encountered:
- Electrical tracingsystem (20 meters had to be changed)
- Metallic pipe changed partially (6 meters)
- Sensitisation emulsion reactor was partially changed (only stator changed).

3.CAUSES:

The temperature gauge was accidently removed from its dedicated location. This resulted in the electrical tracing heated without any interruption since the production was stopped the day before.

The emulsion layer and probably trace of gassing agent inside the metal pipe decomposed due to the heat. Smoke was produced, and the decomposed emulsion was found on a limited portion of the pipe (length of the pipe affected by the phenomena about 60 cm).

The factors potentially causing emulsion thermal decomposition are:

- **Poor design** of the electrical regulation control loop leading to a high temperature on the surface of metal pipes (180°C was the upper electrical tracing temperature).
- The decomposition temperature of **ammonium nitrate** is 170°C.
- Explosive emulsions contain ammonium nitrate (chemical oxidizing product) and water. Once the water has disappeared, the decomposition of Ammonium nitrate can start.
- The presence of an **emulsion layer** inside the metal pipe (230 °c: decomposition temperature);
- Permanent over heating due to **a failure of electrical regulation control**;
- **Confinement** of the emulsion inside the metallic pipe;
- **Traces of gassing agent** were probably present in the pipe.

Laboratory tests showed when the combustion gases were confined at 200°C, some of explosive product reacted to detonation. In our case, the end of the pipe, in the machine was not shut sealed. Combustion gases thus were vented by the pipe.

4.PREVENTATIVE MEASURES:

Remove the electrical trace heating between the emulsion hopper and the Chub machine. It has been necessary to redesign the operating instructions:

- To reinforce the cleaning of the pipe containing emulsion between the hopper and the Chub machine by using a bottle-brush with water under pressure.
- To review the HAZOP study for the whole production line and to establish the correct specifications for the electrical trace heating “self regulating grade or no self regulating grade”

5.KEY LEARNING POINTS :

- The fact that the pipe between Chub and hopper was not confined (presence of a sleeve close to the Chub machine) has reduced the speed of the decomposition to an active combustion.
- Emulsion under confinement when overheated at 230°c is decomposed according to laboratory tests.
- Video monitoring is always extremely helpful to understand the incident (continuous recording).
- Regulation control loop system could fail.