Explosion in a zinc refinery

16 July, 1993

Noyelles-Godault [Pas-de-Calais]

France

Explosion
Metallurgy
Fractionating column
Zinc
Process control
Organisation / Management
Instructions / Procedures
Victims

THE INSTALLATIONS IN QUESTION

The site :

The factory in question is the only French site producing zinc and lead using pyrometallurgical techniques. In 1993, there were only eleven such units that were operational, six in Europe and one in the United States. The facility produces 150,000 tonnes of lead and 100,000 tonnes of zinc from a mixture of zinc and lead sulphide. Some of the impurities such as copper, cadmium, antimony and especially germanium (30 tonnes/year) are recovered. The site regulated by 14 prefectoral orders under the classified facilities legislation is also subject to the SEVESO legislation of 24 June 1982 for two of its activities (production of calcium arsenate and storage of liquid sulphur dioxide). The zinc refining activity did not come under the nomenclature of classified facilities.

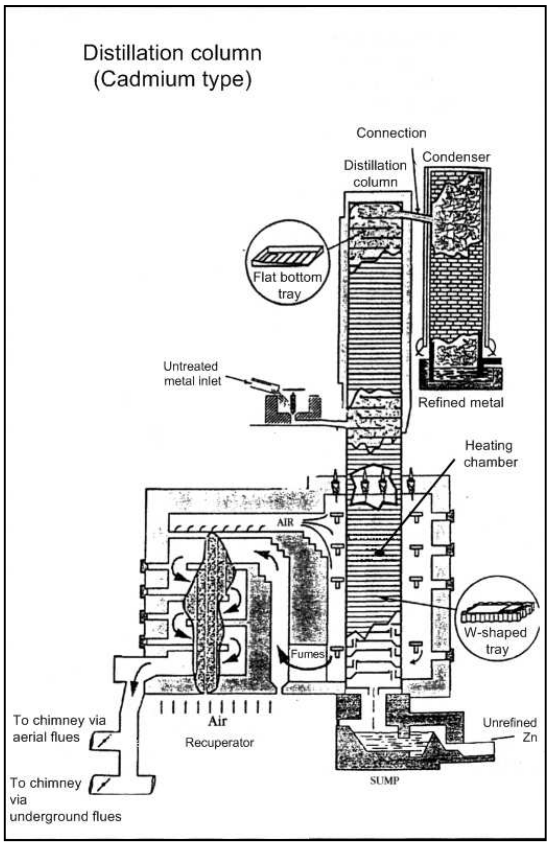
The facility concerned :

The accident concerns a facility that refines zinc by fractional distillation. Liquid zinc at a concentration of 98.5% is received from the blast furnace through 4 tonne ladles and purified to obtain a commercial quality containing less than 50g/t of impurities.

The facility comprises furnaces and 12 fractionating columns that separate zinc from other metals especially cadmium. The columns initially designed under the American "New Jersey" licence are all based on the same principle and technology. The metal is to be treated is fed at the middle of the fractionating column. The lower part is heated to vaporise the metal. The metal vapours are then recovered at the top of the column in an external condenser and the liquid metal is collected at the bottom.

The concerned "cadmium" column is 13m high and comprises a stack of 59 silicon carbide trays heated to 1,000°C. A briquetted heating chamber built around the lower part of the column houses eight natural gas burners and a smoke heat recuperator. The chamber is maintained in low pressure. The top tray of the column is connected to a condenser by a pipe.

The facility is operated by controlling the temperatures at the various places. This is done by manually regulating the intensity of burners and adjusting the opening and closure of smoke flues. The pressures are neither measured in the heating chamber nor in the condenser. Maintenance essentially involves reabsorbing the zinc oxide that



frequently leaks between the trays. The operation is carried out by manholes on the walls of the heating chamber that are blocked by stoppers during the operating phase. The stoppers are just inserted and grouted with clay. Leakage of zinc at the spouts of the sidestream also requires intervention on an average of once per month.

The columns operate continuously for 18 months. Any major stoppage or cooling causes the trays sensitive to thermal shock to break. After this time period, the column is completely dismantled, the heating chamber and flues are cleaned and a stack of new trays is prepared.

THE ACCIDENT, ITS BEHAVIOUR, ITS EFFECTS AND CONSEQUENCES

The accident :

The accident occurred on 6 July 1993 on a cadmium vaporisation column that was re-commissioned on 25 May after being reconditioned (new stack of trays and new flues). The actual production phase started on 24 June with the load being less than the nominal capacity.

The previous day around 5.00 p.m. the technicians were alerted by a strange rumbling noise that was never observed on a recently refurbished facility. A control devise signalled an increase in temperature of the recuperator and major chocking ; a quantity deemed exceptional of 150 kg of zinc oxide was recovered.

On the morning of the accident at 10.00 a.m., it was reported during the daily production meeting that a leak was detected in the heating chamber in the morning. When the pressure in the recuperator was manually measured, overpressure and increase in the temperature of the fumes was noted. Various measures were taken to bring the functioning back to normal. Between 12.00 and 12.25, the thermal condition of the recuperator was more or less stabilised with temperatures being brought back to what was considered normal by the operator. However around 12.10, there was a sudden drift in the lateral temperatures measured in the heating chamber.

At 12.25, eleven people including the production manager, workshop supervisor and experienced technicians, temporary staff and external firebrick layers were working in the immediate surroundings of the column. The sub-contracting staff was repairing the external spout of the zinc sidestream following a leak detected on the same day at 4.00 a.m. the other people were called due to operational problems. At 12.34, several manhole covers of the heating chamber and the recuperator were ejected due to a sudden internal overpressure. A deafening explosion sound was heard by the staff in the control room at about 10m away. A burning cloud escaped forming a white opaque fog (zinc and zinc oxide power vapours?) and spread throughout the workshop in a few minutes. The internal emergency services arrived in 3 minutes.

The consequences:

- ✓ Human casualty

The 11 employees were seriously injured. One of the welders at the lower part of the column died on the spot. Nine other people died in the minutes, hours and days that followed. The only survivor sustained 90% burns.

- ✓ Material damage

Outside the column, material damage in the workshop was limited. The brickwork of the heating chamber showed no signs of internal overpressure. Inside the column, the trays collapsed and the openings for the evacuation of hot gases to the recuperator were partly clogged by the zinc oxide powder. The outside of the building suffered no damage.

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

Level 1 attributed to the dangerous materials released index characterises the explosion produced (parameter Q2 : quantity of explosives substances in equivalent of TNT < 100 kg).

Level 4 attributed to the human and social consequences index is explained by the death of 10 people.

However, the unavailability of statistical information makes it impossible to rate the economic consequences index.

ORIGIN, CAUSES AND CIRCUMSTANCES OF THE ACCIDENT

Administrative and third-party expert enquiries were carried out. A legal enquiry was ordered and three experts were appointed. The "administrative" investigations were made difficult due to the absence of qualified witnesses, limited recorded data and the legal enquiry (limited accident reports, prohibiting staff hearing, etc.). The accident was subsequent to strange noises that indicated a disturbed boiling flow and load inside the column. According to the general opinion, the rupture of trays is the reason behind the accident. The rupture could have occurred due to a quality problem or a thermal shock during the preheating phase or when supplying the column for the first time.

It was then decided to reconstruct the facility while taking special precautions for receiving the trays. The preheating procedure of the column was modified : the slope of the temperature rise curve was brought to 4°C/h from 5°C/h. New control instruments were also put in place (pressure measurement at the bottom of the heating chamber and outlet of recuperators, replacement of recorders in the control room, measurement of oxygen level in the fumes). The column was rebuilt in 1993, preheated and resumed production on 17 January 1994 at a reduced pace. On 24 January, there was an explosion with emission of a zinc oxide cloud. A subcontractor present at the area prohibited following the first accident around the facility (zone physically accessible) was killed.

Subsequent to the enquiries and expert reports on the two explosions, it was assumed that the column was flooded due to the poor off-take rate of zinc at the foot (partial clogging of the siphon spillway of the liquid metal or excessively high viscosity of zinc during the start-up phase of the column). The rising level of zinc inside the column, the release of zinc vapour bubbles caused vibrations leading to the rupture of trays and then the column resulting in the emission of zinc vapours and suspension that exploded on contact with the atmosphere of the heating chamber.

The expert reports have also underlined:

- ✓ Lack of rigour in operations and absence or limited written procedures
- ✓ Absence of general awareness on risks of explosion,
- ✓ Poor safety management at the level of both internal communication and scientific and technical knowledge of the facility

ACTION TAKEN

At the time of the accident, the refining activity did not clearly come under the nomenclature of classified facilities for environmental protection. A prefectoral order of 11 January 1994 issued recommendations to the operator to carry out a study on the danger to the environment and to the other high-risk facilities of the site (under article 5 of the "Seveso" Directive).

The nomenclature of Classified Facilities was modified by a decree dated 29 December 1993 that subjects activities involving treatment, production and refining of non-ferrous metals and alloys to authorisation under the heading no. 2546.

Following the second accident on 24 January 1994, the Prefecture subjected the re-commissioning of the zinc refining facility to a new licence under the classified facilities legislation. The activity was approved by the prefectoral order of 13 March 1995. The factory shut down in the beginning of 2003.

On 25 September 1997, the District Court of Béthune sentenced the Plant manager to two years of suspended imprisonment and a fine of 30,000 francs. The Technical operations manager was sentenced to 18 months of suspended imprisonment and a fine of 30,000 francs. The company was declared to have incurred third party liability.

LESSONS LEARNT

Following the two accidents, the reconstruction and commissioning of a new column was subject to improved instrumentation, tightening of new tray assembly and removal procedures, verification of the conditions of increase of the column temperature, monitoring of columns operations from the control room and early detection of abnormal functioning.

The following measures were also taken to reduce the impact of an accident on a refining column :

- ✓ Weakening of the upper part of the façade before the heating chamber allowing pressure to be released in an unoccupied area,
- ✓ installation of protective screens against thermal flows and projectiles,
- ✓ limitation of occupancy in work stations exposed to maximum risk,
- ✓ implementation of guidelines regulating movement of personnel in danger areas,
- ✓ use of personal protective equipment adapted to the operations,
- ✓ implementation of an emergency procedure to stop operations, evacuate staff and close danger areas.

In addition to the circumstantial lessons learnt from the facility, it was observed that :

- ✓ feedback from other accidents that occurred in the world was not taken into account (mistake also indicated by the court),
- ✓ blatant organisational errors were committed.