Ignition of a wood dust cloud in a production unit

11 May 2004

Allouville-Bellefosse - [Seine-Maritime]

France

Explosion
Particle board
Press
Wood dust
Inadequate intervention
Lack of procedure
Inattention to risk
Cleaning
Extinguisher
Training
Victims

FACILITIES INVOLVED

The company is specialised in manufacturing wooden or flax shive particle boards.

The installed load of facilities whose capacity was increased in 2003 is subject to prefectoral approval (50 MW for thermal drying, 4.5 MW for wood chipping and around 2 MW for sawing and sanding). The industrial site produces 500,000 m³ of particle boards per year. It operates round the clock with two annual stops in August and December.

The production process diagram is illustrated below:

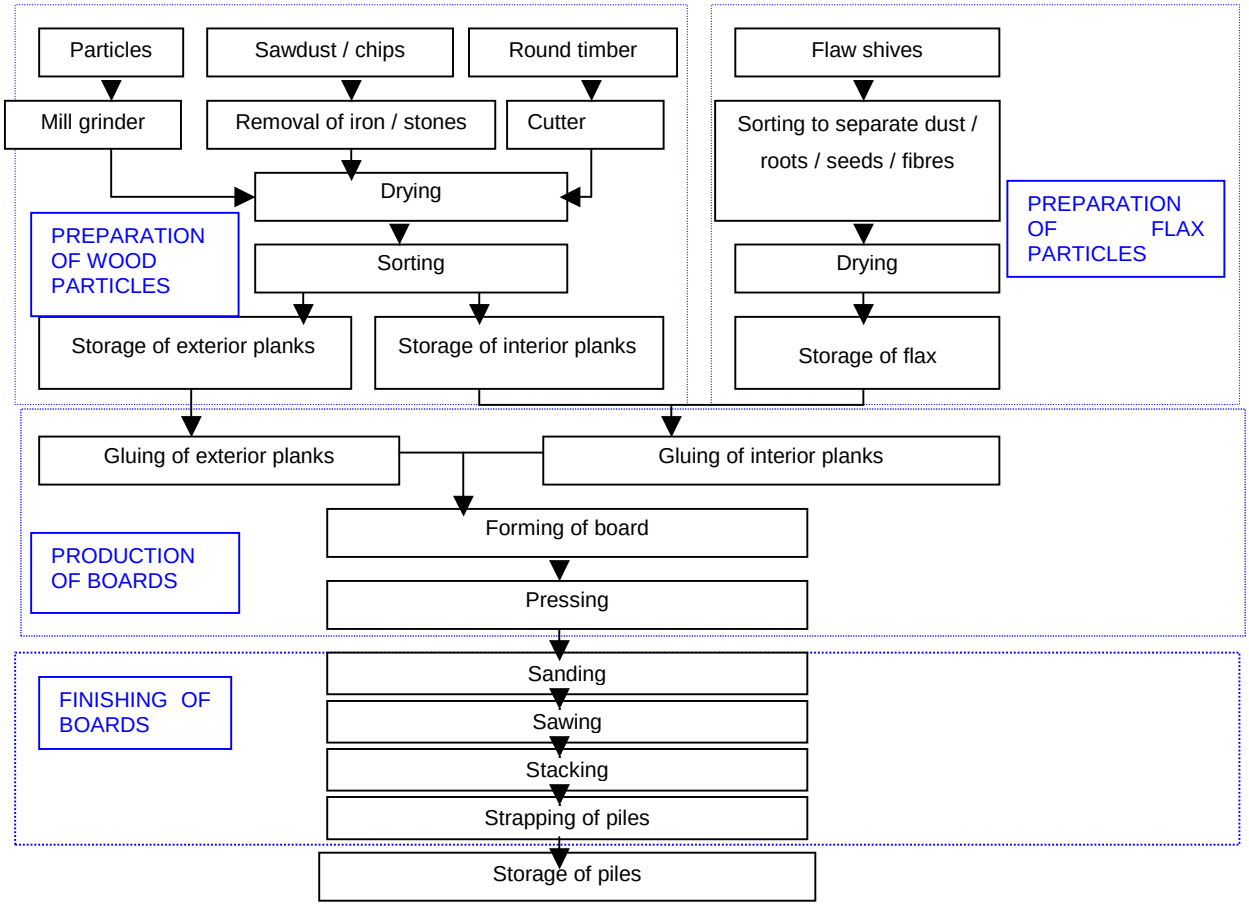


Figure 1: Particle board production process diagram

Particle board production can be divided into three stages:

- Wash coating particles using urea formaldehyde resin,
- Forming that involves spreading materials to form a mat on metal sheets,
- Pressing where the mat is placed in a heated hydraulic press to polymerise the resin.

The hydraulic press involved in the accident had been installed for eight years and was modified in 2002 to increase the production capacity (from 8 to 11 levels). The temperature was increased using a mineral oil heated to 250 °C and distributed by a circuit regulated between 140 and 210 °C.

The process inherently generates wood dust. For instance, 60 tonnes of wood dust are produced per day just from the final board thrust.

THE ACCIDENT, ITS CHRONOLOGY, EFFECTS AND CONSEQUENCES

The accident:

On Tuesday 11 May 2004, a dust cloud ignited at 6.45 a.m. just above the press when two technicians were trying to put out a smouldering fire with a dry powder extinguisher.

The consequences:

The consequences of the accident were dramatic with the death of one technician while the other sustained serious burns.

The material consequences were limited. Since the accident occurred in a relatively open area, the pressure surge was limited. The fire was brought under control by triggering the automating sprinkler system. Since the rescue centre was only a few kilometres away, fire services arrived quickly to put out the fire on a part of the roof where the asphalt coating was burning.

Operating losses were significant with the shutdown of production for 10 days. Operations could be resumed only after an analysis report was submitted, as required by the “emergency measures” order.

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.developpement-durable.gouv.fr

Level 1 attributed to the "Dangerous materials released" index characterised the explosion (Q2 parameter: quantity of explosive substances equivalent to TNT < 100 kg).

The death of a technician explains the level 2 ascribed to the human and social consequences index (H4 parameter).

Since material damage and operating losses were not estimated by the operator (parameters €15 and €16), the economic consequences could not be stated.

THE ORIGIN, CAUSES AND CIRCUMSTANCES OF THE ACCIDENT

Since the accident was serious, an analysis of accident circumstances along with the establishment and implementation of corrective and preventive measures were ordered. The company entrusted the investigation to a design office specialised in dust explosions.

The circumstances surrounding the accident:

On the day before the accident, the team on the night shift (9.00 p.m.-5.00 a.m.) detected a burning smell in the unit without being able to trace its origin. The team on the morning shift (5.00 a.m.-1.00 p.m.) located the smouldering fire at 6.00 a.m. below the press.

A mechanic and an electrician used an aerial lift and found embers on the upper heat transfer plate of the press. After informing the team supervisor, a decision to empty the press and stop the production line before carrying out any operations was taken. The production manager who was still at home was informed by telephone.

The team supervisor and the electrician went up to the level of the embers with a 50 kg powder extinguisher wearing P3 cartridge neoprene masks. A scraper was brought on site to recover the burning material. To put out the fire, the embers were sprayed with one or two rounds of powder using the extinguisher. This is when, around 6.45 a.m., the suspended dust particles were ignited triggering a full-blown fire in the entire zone surrounding the press. The aerial lift with the two employees was blocked in the structure. The team supervisor managed to come down on his own despite the burns sustained, yet could not save his colleague. The electrical technician was found dead in the aerial lift.

Origin and cause of the accident:

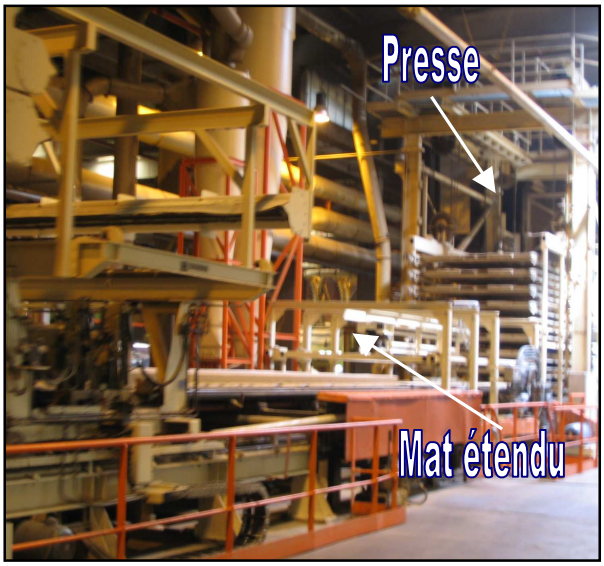
The eleven stages of the press, which measures 9.50 m by 5.50 m, were subjected to high temperature and pressure constraints. To compensate for any possible deformations of the end plates, the manufacturer had installed a heat transfer plate divided lengthwise into three control zones above and below the press.

The temperature of these control zones was adjusted by the company. Based on experience, it was seen that beyond a temperature of 165°C, dust particles in the vicinity were ignited. The maximum recommended temperature was set at 140°C.

Transformation of the press

When the press was modernised (i.e. upgraded from 8 to 11 stages), the last plate was very close to the heat transfer plate. For production reasons and throughout the entire start-up period (July 2002 to January 2003), plate temperature was decreased from 190-215°C to 170-190°C.

In January 2004, when the temperature of the plates was increased, and even when the central zone of the heat transfer plate was not heated, the temperature still reached 165°C. Ignition of the dust particles was again observed. These incidents were deemed of no major importance and thus not reported to the Hazardous Installations inspection authority. The company decided to cool the central zone instead of heating it. The plate was supplied with a coolant from a cold source. All the equipment (pumps, piping) was operational as of April and the temperature of the central zone was set at 140°C.



Forming line and press – Photo DRIRE

Triggering event

An incident was recorded in the electrician's report on the eve of the accident, around 10:00 am. The control room operator recorded an excessively high temperature reading in the heat transfer plate (exceeding 200°C). The electrician and mechanic observed that the temperature control functioned normally but not the three-way control valve, which remained partially open at the heat source. They therefore manually shut the three-way control valve and out of precaution, a manual valve and the area circulating pump as well.

The temperature decreased gradually and by around 4.00 pm was near 150°C.

The expert analysis of the three-way control valve subsequently revealed the presence of a hard point that explained its blocked state since the valve was driven by a low power servomotor.

An incandescent dust deposit

The press is stopped and cleaned only once or twice a year (the plate is hard to access and the extreme temperature makes it impossible to carry out maintenance during operations). At the time of the accident on May 11, a 10-15 cm layer of wood dust was present. When the temperature control problem arose, the temperature climbed to above 200°C, thus crossing the spontaneous combustion temperature level and the dust layer started to burn. The stream of air from the fire extinguisher created a suspended cloud of wood dust under explosive conditions in the presence of incandescent particles.

ACTIONS TAKEN

In the week that followed the accident, the company repaired and carried out inspections on the damaged equipment. It also implemented temporary and more stringent monitoring measures that mainly involve recoding the fluid temperature readings on paper and defining a procedure to deal with any subsequent temperature increase incident.

Since the accident claimed lives, the inspection authorities for hazardous installations involved both the Labour Office and the Regional Social Security Administration in their efforts, which led to exposing the difficulties experienced by the company in properly assessing the level of professional risk. This observation limited the extent of procedures proposed by the operator in resuming its activities at the facility.

The issuance of an emergency order subjects activity resumption to in-depth investigations. The scope of the study covers the press and its range of uses; moreover, the company is requested to undertake a comprehensive study program that examines the entire site. To assist in this analysis, the company commissioned a certified expert specialised in dust explosions.

Immediate measures required prior to resuming operations

In order to place the facility back into operation, several preliminary measures, set forth in conjunction with the expert, had to be adopted:

✓ Temperature control:

With respect to the heat transfer regulation zone, since exterior zones no longer need to be heated subsequent to press modernisation work, the heating circuits were to be definitively closed.

Three temperature probes were added as backups, with each indicator based on the fluid reading, along with 2 alarm thresholds (a 1st threshold set at 142°C for notify the presence of an anomaly and the 2nd at 160°C to shut off the burner on the boiler).

✓ Limitation of dust accumulation

In its analysis report, the expert indicated that in the auto-inflammation of a dust deposits, a relation exists linking deposit thickness with the temperature surrounding the deposit.

In this special case, ignition is possible at 240°C (temperature of the coolant fluid upon exiting the boiler) for a 5-mm thick layer. When the thickness reaches 7 cm, ignition temperature drops to 160°C, a value threshold that the backup measurement system installed by the operator must be able to avoid.

Nonetheless and as a precautionary measure, indicators have been placed 5 cm from the surface of the last plate and are read visually twice a week, with all recordings being logged. The press is to be stopped and suction cleaned as soon as the dust deposit has reached the thickness indicator point (every 10 to 15 days of operations).

The assigned expert has specified that the limits of dust accumulation thickness are only provided for indicative purposes (as product knowledge still needs to be refined) and only pertains to extinguishing smouldering fires. In reality, such thicknesses are more than sufficient, in the case of suspended dust particles, to cause triggering an explosion.

✓ Description of the protocol to be employed

According to the facility operator, several fires had already broken out on the installation since service start-up as a result of errors committed when adjusting the temperature setting established for the plates in question. These fire outbreaks occurred on the hot parts (e.g. lighting), given that the incandescent part had been picked up with a whisk broom or scraper, yet the consequences from these incidents were considered to be of minor importance. On May 11, 2004, in the absence of written guidelines concerning the operating procedure to follow in the event of fire outbreak, the employees tried using an extinguisher.

As a result of this dramatic accident, a set of written procedures were drawn up and explained to the staff on appropriate responses under various circumstances, including:

- the procedure to follow should an abnormal temperature rise be noticed,
- steps to implement upon detecting a burning smell,
- the press cleaning protocol, and
- action procedure in the case of smouldering fires.

✓ Press prevention and protection measures

Thermal insulation has been placed on top of the press so as to insulate the hot surface from dust deposits. Fixed watering ramps have also been installed to enable cooling and extinction from the floor, without therefore having to use an aerial lift should a fire ignite above the press, which is not protected by the sprinkler network.

✓ Personnel training

A special training session devoted to handling extinguishers has been organised for 15 staff members (i.e. 3 per team).

✓ Executive commitments

The company has formalised its commitment to:

- pursue studies ordered by the expert for the purpose of delimiting zones with explosive atmospheres (ATEX directive),
- seek solutions targeting dust extraction at the source and centralised suction cleaning, and
- personnel training in risk management and introduction of the single document system (workplace rules).

Complementary prescriptions adopted to strengthen site safety

The measures adopted have made it possible to authorise the resumption of facility activities on May 22, 2004, after completion of the personnel training sessions in operating the extinguisher. The ten-day shutdown had placed the company in financial difficulties, in addition to causing hardship to some twenty fibre processing plants and a good number of clients positioned both upstream and downstream of the production stage (500 jobs in all).

The Hazardous Installations Inspectorate proposed afterwards another legal order intended to repeat the series of measures identified so as to authorise plant start-up. This order, prepared in close collaboration with both the Labour Inspectorate and local Social Security Office, imposed conducting further studies that encompass the entire site. Such studies are aimed at mitigating, at their source, the risks engendered by these installations, according to a four-pronged approach:

- identifying dust emission sources and, if applicable, the measures that serve to reduce emissions;
- assessing the pertinence of cleaning procedures and methods, the amount of resources implemented (suction equipment, equipment and operator protective devices, secure access to the cleaning zones, human resources, etc.), and the personnel training courses;
- circumscribing all zones containing explosive atmospheres, in addition to determining the associated equipment and developing a programme for ensuring compliance with applicable regulations (ATEX); and
- designing and allocating protection resources to counter the effects of an eventual pressure surge (vents, explosion suppressor, etc.), as well as for loss prevention purposes.

Mechanical transport system with screw-activated decoupling. Photo courtesy of: Drire

The modifications introduced on site installations have served to limit dust deposits on the press, while facilitating cleaning of the various workspaces through a centralised suction system.

The study of hazards will serve to define a number of improvements, including moving the dust silos and resizing pressure vents. It has also placed emphasis on the risks introduced by facilities devoted to pneumatic sawdust transport devices, with preference given to a slow mechanical transport that allows instituting a decoupling system.

These installations are protected from the outset against explosion risks. More specifically, watering ramps connected to spark detectors have been installed over a large portion of the circuit. On average, these devices record 400 detections a month. This high number would no doubt contribute to the insignificance ascribed to the phenomenon within the company.

The study on equipment compatibility with "ATEX" directive specifications has led to launching a major programme of additional investigations and physical modifications.

Some thirty procedures and guidelines have been adopted for running the installations, whose application remains contingent upon adequate personnel training.

Lastly, a safety manager staff position has been created and filled.

Dryer – Photo courtesy of: DRIRE

LESSONS DRAWN

Among the feedback from this accident, the following stand out as being the most critical:

✓ Despite being exposed to fire and dust explosion risks, the local particle board manufacturing industry was insufficiently prepared to apply the regulations stemming from application of the "ATEX" directive. The local Inspectorate of Hazardous Installations will also impress upon the department's flax processing operators these requirements, since these plants are subject to similar constraints.

✓ Measures consisting of reducing dust emissions at the source and avoiding dust accumulation are necessary for fire and explosion risk prevention. Moreover, airborne concentrations at the workstation is limited by regulation, since June 30, 2005, to 1 mg/m^3.

✓ Changes in personnel behaviour, e.g. assimilating written procedures, are difficult to obtain in the absence of well-adapted training sessions. In this respect, cooperation with the local Social Security Office and Labour Inspectorate have generated a number of complementarities.