



Combustible Dust Explosions at Gallatin Plant

An Online Continuing Education Course for Engineers

Course Number: H-1005

Credit: 1 Hour / 1 PDH / 1 CPD

Combustible Dust Explosions at Gallatin Plant

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INTRODUCTION

For workers at Hoeganaes's Gallatin, Tennessee plant, flash fires in the processing areas were a common occurrence. Although the incidents were routine, many employees weren't aware of the properties of the combustible iron dust that was visibly present in the air and coated the surfaces of the facility— up to four inches thick in some areas. Nor were they aware of the severity of the hazard. The company required employees to wear fire-proof garments at the plant that produces atomized iron powder for industrial customers. However, there hadn't been any fatalities before a January 31, 2011 flash fire that claimed the lives of two (2) workers.

Another serious incident occurred in a March 29, 2011 flash fire that injured an engineer. Then, on May 27, 2011, while Hoeganaes Vice President of Human Resources, Mike Mattingly was in Gallatin to attend the funeral of an employee who died from burns he sustained in the January flash fire, a third serious incident occurred.¹ A hydrogen explosion killed three employees and injured several others and caused multiple flash fires in the facility.

An investigation of the three incidents found inadequacies in Hoeganaes Gallatin's design, management, and operations.

- The hazard addressed by combustible dust was ignored and housecleaning and ventilation systems were inadequate.
- The design of the plant and equipment contributed to significant accumulations of combustible material.
- Employee training was inadequate.
- Gas pipes were not inspected.
- Areas were not tested for the presence of explosive gases prior to maintenance.
- Recommendations for fire prevention in the presence of combustible dusts were not followed.
- Flame-resistant clothing provided to employees didn't provide any significant protection from the flash fires and explosion.

The week prior to the fatal May incident, the Tennessee Occupational Safety and Health Administration (TOSHA) fined Hoeganaes \$42,900 for 12 serious violations found in investigations of the January and March accidents.² Later, TOSHA fined the Hoeganaes Corp. \$80,000 for 23 serious violations in the May incident.³

Hoeganaes received fifteen (15) OSHA PSM Standard violations for the May 2011 incident. TOSHA found that the company lacked appropriate procedures to ensure mechanical integrity of the hydrogen piping, failed to develop an emergency response plan for leak detection and response, and did not perform a hazard assessment on the hydrogen process.⁴

COURSE OBJECTIVES

This course identifies factors in the design and operations of the equipment and facilities that led to the three serious incidents at Hoeganaes Gallatin. Some of the key issues relate to regulatory concerns and the activities of state, local, and federal agencies; while these issues will be mentioned, the focus of the course is the engineering and operational aspects.

Readers are encouraged to consider the following issues as they relate to the incidents at Hoeganaes Gallatin.

1. How did design factors contribute to the incidents? What modifications to the designs might have improved safety?
2. How did management and operational decisions contribute to the incidents?
3. What shortcomings were present in the plant's training, safety precautions, and procedures? How could the incidents have been avoided?

GKN HOEGANAES

Hoeganaes states that “The company provides iron powders, atomized unalloyed steel powders, atomized low alloy steel and metal powders, ancorsteel phosphorus alloys, and brazing powders. Its products are used as raw materials in the manufacture of structural parts, filters, and bearings, as well as in the manufacture of iron-based compounds.”⁵

The company has operations in Romania, China, the U.S., and Germany. The U.S. facilities are in Gallatin, TN; Ridgway, PA; Watsonstown, PA; and Cinnaminson, NJ, the U.S. headquarters.

The Gallatin facility is located 30 miles northeast of Nashville, TN. It employs slightly fewer than 200 employees and has a manufacturing capacity of over 300,000 tons.

GKN Hoeganaes Corporation describes itself as “the world leader in the production of Atomized Steel and Iron Powders. We cover the globe with facilities in Asia, Europe and the Americas.”⁶

Hoeganaes was acquired in 1999 and is a subsidiary of GKN, a British global engineering group.

GKN describes itself as “The world’s leading supplier of driveline systems and solutions”, “The No.1 producer of powder metal (PM) components”, “A first tier supplier to the global civil and military aviation industries” and “A global engineering leader of integrated PowerTrain technology.”⁷



Hoeganaes Gallatin Plant. (Source: CSB.)

THE PROCESS⁸

Hoeganaes produces PM by melting scrap steel. It's main product Ancorsteel 1000, contains more than 99% iron. Most of the fine PM product has a particle diameter between 45-150 microns.

The primary market for PM is the automotive industry.

Based on customer specifications, additional elements are added to the molten iron. The iron is then cooled and milled into a coarse powder.

A 100 foot conveyor belt moves the powder through annealing furnaces, called "band furnaces", to make the iron more ductile, producing a thick sheet referred to as "cake".

The furnaces contain a hydrogen atmosphere to remove oxides and prevent oxidation. Hoeganaes purchases the hydrogen from an on-site contractor and trenches under the floor contain pipes that move the hydrogen to the furnaces.

After the annealing process, the cake is crushed into fine PM particles.

Iron is transported through the plant by a system of conveyors and bucket elevators.



Iron is transported through the plant by a system of conveyors and bucket elevators. (Source: CSB.)

COMBUSTIBLE DUST

The dangers of iron dust and all combustible dusts are well-known. In fact, any dust is combustible, given the right concentration, oxygen, and an ignition source. An Occupational Safety and Health Administration (OSHA) Fact Sheet begins:

“In addition to the familiar fire triangle of oxygen, heat, and fuel (the dust), dispersion of dust particles in sufficient quantity and concentration can cause rapid combustion known as a deflagration. If the event is confined by an enclosure such as a building, room, vessel, or process equipment, the resulting pressure rise may cause an explosion. These five factors (oxygen, heat, fuel, dispersion, and confinement) are known as the “Dust Explosion Pentagon”. If one element of the pentagon is missing, an explosion cannot occur.”⁹

If the primary explosion dislodges additional dust that may have accumulated, a catastrophic secondary explosion or series of explosions may occur. OSHA notes that the secondary explosions “can be far more destructive than a primary explosion due to the increased quantity and concentration of dispersed combustible dust. Many deaths in past accidents, as well as other damage, have been caused by secondary explosions.”¹⁰

Initial Explosion

Secondary Explosion



(Source: OSHA.)

THE INCIDENT

January 31, 2011¹¹

Bucket elevators are used to transport material from the bottom to the top of the plant. The belts sometimes slip off-t

Around 5 a.m. on January 31, 2011, two employees were inspecting a bucket elevator.

The employees concluded that the motor was not working and decided to have the motor restarted. As the motor restarted, a large amount of dust in the air and flames erupted from the elevator.

Both employees suffered serious injuries. The second employee died from his injuries. The second employee died from his injuries.

The U.S. Chemical Safety and Hazard Investigation Board (CSB) investigation concluded that exposed electrical wiring on the elevator motor was the likely ignition source. The motor was not properly grounded, was near the site of the explosion and a witness reported hearing an “electrical sound” prior to the explosion.¹²

The TOSHA investigation noted that the equipment was not locked out prior to beginning the maintenance.¹³

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