Dust explosions: A report on recent major explosions in Argentina and Brazil

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Abstract

In South America, grain elevators have not been exempt from dust explosions. Between 2001 & 2002 there were three major dust explosions, TOEPFER, Puerto San Martin (Argentina), San Lorenzo Terminal (Argentina) and COINBRA, Paranaguá (Brazil), with both great loss of lives and material. This presentation has three specific targets:

1. Explanation of how each of these explosions occurred.

2. How local industries reacted to prevent future explosions and reduce their severity.

3. Reinforce safety issues offering new perspectives on the explosion threat.

In Argentina and Brazil, due to this recent explosion frequency, there is a bigger industry alert on the hazard of grain dust explosions. We will see specifications and regulations to guide the building new facilites.

Facilities must be kept thoroughly clean; dust control systems must be installed and up-graded, together with the installation of adequate electronic hazard monitors which add higher levels of security. I hope this article will help prevent future explosions by alerting and reminding the industry of the need to reinforce safety issues and standards.

1. Introduction

Since these three major explosions happened, as part of my professional and institutional activities, I have been giving presentations on this issue, and I have been astonished to learn of the number of other smaller incidents involving dust explosions, where people have been killed, not only in Argentina, but also in the hot and humid heartlands of central Brazil.

In October 2001, a severe explosion left three dead and seven injured in the Terminal of A.C. TOEPFER in Puerto San Martín, Santa Fe province, Argentina. A month later a similar disaster destroyed the port terminal of COINBRA, Louis Dreyfus´ Brazilian grain subsidiary, in Paranaguá, Paraná State, Brazil. Fortunately, on this occasion, it was without casualties, but it did inflict complete material damage.

In April 2002, the San Lorenzo Terminal exploded in the Santa Fe province, Argentina. The result was tragic: three people were killed, nineteen injured and there was total destruction of the main infrastructure, resulting in millions of dollars worth of lost structures, equipment and material.

Other recent explosions, although less damaging, include the terminal of PRODUCTOS SUDAMERICANOS, in Punta Alvear, near Rosario, Argentina, on the Paraná river, in August 2000; the LOUIS DREYFUS Terminal in General Lagos, north of Rosario (where the world's largest oil-seed crushing plant is located, with a production capacity of 12 000 t per day) - sadly one person was killed in this explosion – and an explosion in a flour silo at MOLINO ARGENTINO (a wheat flour mill) in 1995 in the Buenos Aries metropolitan area that killed three, but incredibly occurred without any material losses. It is not surprising that these explosions occurred, but the frequency with which they have done so in recent years is remarkable. In the previous 15 years, South America had not suffered any serious explosions.

Nevertheless, Argentina has had its share of accidents. One of the largest was in 1990, when we were surprised by the explosion of GENARO GARCIA Terminal in the port of Rosario, resulting in ten deaths. But the worst explosion was the tremendous tragedy that occurred in 1985 at the silos of JUNTA NACIONAL DE GRANOS, in Bahía Blanca, an ocean terminal, killing twenty-two and injuring more than ten people.

2. TOEPFER Puerto San Martín explosion, Argentina

The explosion happened in a tunnel underneath five steel bins during lunch on a sunny and dry spring day, one hour after loading a ship. Parallel and beside these bins there was a horizontal flat warehouse, that was empty, where five workers were doing civil maintenance works. Between the steel bins and the horizontal warehouse there was a connecting tunnel, that held a belt conveyor that collected both from these silos, the warehouse and from others, conveying to the shipping bucket elevators (Fig. 1).

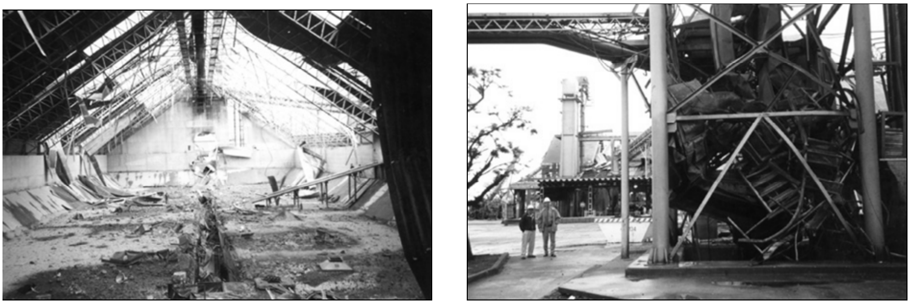

Figure 1 TOEPFER Puerto San Martín explosion (Santa Fe, Argentina) October, 2001

The first or primary explosion started underneath the steel bins, in the tunnel. Standing dust on the floors and edges was stirred up by the shock wave caused by this primary explosion, and provided the fuel for a secondary explosion, which was much more violent than the first, expanding quickly through the connecting tunnel to the tunnel underneath the warehouse, where the workers were. The warehouse was empty but two workers inside the tunnel were killed instantly and a third, working on the floor of the warehouse, was killed as the concrete tunnel roof blow up. A chain reaction of ever-increasing intensity had been set in motion that culminated with a third explosion that completely destroyed the reception area (about 300 m away from the starting point), and other concrete and metallic structures.

Curiously, the conveyor belt had stopped operating inside the tunnel where the explosion had started one hour before the explosion. Therefore, everything was still and quiet, and there was no dust-air mixture in suspension. An ignition source of sufficient energy, temperature and duration to initiate the explosion had to be present. Without an electrical spark or an overheated bearing in a confined area with fuel, and with no dust in suspension and nothing moving in the tunnel, an explosion seems impossible!

Experts think that the TOEPFER explosion was due to hexane gas rather than grain dust. Since rebuilding of the facility, hexane monitors have been installed in the tunnels which will detect gas leaking into the tunnels under the storage from the crushing plant next door. Steps were taken on both sides to correct this dangerous situation.

3. COINBRA Paranaguá explosion, Brazil

Again the explosion occurred at midday, whilst loading maize onto a ship, so luckily the main personnel were out for lunch, and no one was killed. Nevertheless, six people were injured, and there was massive damage to the facility. The information I have on the causes is acquired from the testimonies of people operating the neighboring terminal, who witnessed the explosion and whose facilities also suffered serious damage from huge pieces of airborne concrete that hit their facility during the explosion (Fig. 2).

The explosion started in the shipping bucket elevators were in operation, and was most probably due to belt misalignment. This primary explosion expanded quickly throughout the whole facility. The first explosion caused dust within the facility to be blown into suspension in the air, thereby contributing to a series of subsequent much more powerful secondary explosions. The secondary explosion was so strong that all resistant structures collapsed, even rail cars were turned over like toys, big pieces of concrete that weighed over 5 t were blown 300 m away, the steel shipping tower collapsed to earth. The destruction was followed by fire, which ignited the grain and continued burning for nearly three weeks.

 

Figure 2 The COINBRA Paranaguá Terminal explosion (Paraná, Brazil) November, 2001

4. Terminal San Lorenzo explosion, Argentina

This facility had a comprehensive housekeeping program that ensured dust accumulations were promptly and regularly cleaned. It included a brand new and highly efficient dust collection system, fitted with modern filters (bag houses) with low pressure automatic cleaning. A thorough maintenance program was in place as well as a training program for employees and contractors on the hazards of handling and collecting dust.

The explosion occurred while loading soya onto a ship on a dry and sunny autumn day. Again, luckily, the main group of personnel was out for lunch. Even so, the explosion left three dead, nineteen injured, and caused massive destruction of the terminal (Fig. 3). They had been loading a ship that was receiving simultaneously from three spots: from the horizontal silo, directly from trucks through the receiving pits and directly from railcars

Figure 3 The San Lorenzo Terminal explosion (Santa Fe, Argentina) April, 2002

All three spots were connected through a tunnel that collected from the horizontal silo, passed through the truck reception pits, through the railcar pits and continued to the shipping header house tower that supported the shipping-bucket elevators. This header house was built on a concrete structure, but with no walls, that could have helped to stop or deflect and dissipate the power of the destructive explosion energy wave.

An unknown ignition source ignited dust within the facility and resulted in a series of explosions that severely destroyed the heart of the port facility. The actual ignition source may never be known due to the damage that occurred in the tunnel beneath the horizontal silo, where the first or primary explosion started, and because the employee working in this area at the time of the explosion was killed.

This underneath tunnel in the flat storage, connected to another underneath collector tunnel, an underground avenue that led to the shipping tower. The collector tunnel collected grain from the truck reception area, from other tunnels under other horizontal warehouses and from the railcar reception area arriving to the bucket elevator pits in the shipping tower.

This underground infrastructure was a long network of confined spaces that distributed and accelerated the propagation and intensity of the explosion. A second worker was killed while operating the railcar gates and a third was found dead 3 days later in the shipping bucket elevator pit, 15 m below ground level, were the shipping tower stands.

Figure 4 The San Lorenzo Terminal explosion (Santa Fe, Argentina) April, 2002

4.1. San Lorenzo terminal reconstruction

The former idea of extended interconnecting conveying tunnel lay-outs with no bucket elevators has changed. It is now believed that the installation of bucket elevators will prevent the transmission of primary explosions to the rest of the facility.

It is interesting to observe the thinking behind the reconstruction. The design is supported by three main axes designed to minimize or eliminate confined spaces.

4.1.1. Minimizing explosion risks

- Eliminating tunnels where possible and instead using open galleries and catwalks that operate above ground, loaded by new bucket elevators at the end of each horizontal warehouse.
- Confining the risks to certain sectors by installing a bucket elevator at the end of every tunnel, eliminating connections between tunnels, avoiding the propagation of the explosion.
- All the mechanical handling is now fitted with hazard monitors, controlling speed, belt misalignment, belt slip, plugging and maximum belt extension, with emergency stop.
- The elevator towers are open and made of steel. Elevator pits are also open.

4.1.2. Reduction of environmental pollution

- Replacing cyclones with low pressure filters (bag houses).
- Adding thirty three aspiration systems with filters (bag houses), that collect the dust emitted during operations, in different sections of the facility.
- Installation of a white mineral oil application system for dust emission control.
- Installation of dust suppression systems in two of the four ship loading tubes, with telescopic hoses, minimizing the dust emission during loading of a vessel.

4.1.3. Increasing operational efficiency

By reducing belt speeds and increasing capacities, with wider belts to reduce dust generation. For example: Previously the shipping belt ran at a capacity of 1000 t/h at 400 m/s. By comparison, in the new facility the same conveyors run at a capacity of 1200 t/h at 300 m/s.

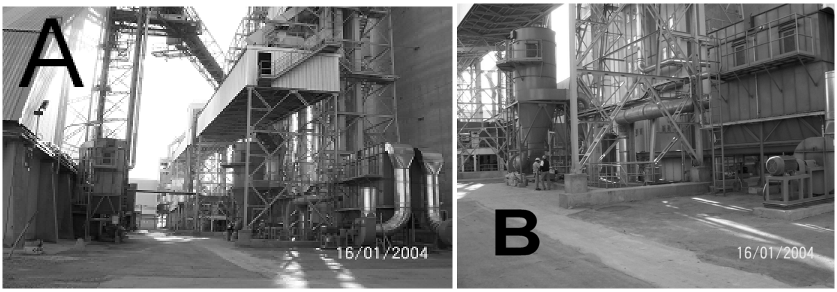

Figure 5 San Lorenzo terminal reconstruction: A. Open steel galleries above ground. B. Some of the 33 large aspiration systems with filters (bag houses) and open elevator pits

5. How the grain industry responded

In South America, there is still no specific legislation to prevent dust explosion hazard. However, in Argentina and Brazil, due to the frequency of recent explosions, there is now greater awareness within the industry on the hazard of grain dust explosions. Our vegetable oil industry is both very strong and conscientious so the companies are applying North American specifications and regulations to orientate new facility designs. Facilities are kept thoroughly clean, mineral oil applications are frequent, and dust control systems are installed and up-graded. The installation of adequate electronic hazard monitors is adding higher levels of security.

In order to assure that an explosion is not produced, the equation "dust + oxygen + confinement + ignition" must be altered. The elimination of any one of these requirements will prevent the reaction. This can be done by neutralizing ignition sources or eliminating or reducing the emissions of dust. Dust is eliminated by controlling its generation or installing vacuum systems that collect the dust in filter sleeves at each point of emission.

Sources of ignition can be eliminated principally by preventing electrical failures, by use of adequate non-explosive materials (cables, lighting, electrical components and motors) in equipment, and plants that are well designed and maintained. Mechanical failures, like the temperature of bearings and slipping and misalignment of the belts, can be controlled by the installation of adequate electronic monitors. These automatic monitors add a higher level of security as they are connected to an alarm system and are strategically located so they can shut down a conveyor and/or the entire facility if necessary.

Modern plants are constructed with extended lay-outs, to avoid elevators and confined spaces where possible, but some will always exist out of operational necessity: bucket elevators, tunnels under silos, linking tunnels, etc. It is very difficult to prevent an explosion. However, it is always possible to minimize the damage by designing light open structures and explosions reliefs that can dissipate the pressure created by a ‘primary’ explosion. Using openings that act like vents to prematurely dissipate the initial pressure wave and avoid its destructive and lethal propagation.

Figure 6 Open towers and explosion reliefs for tunnels.

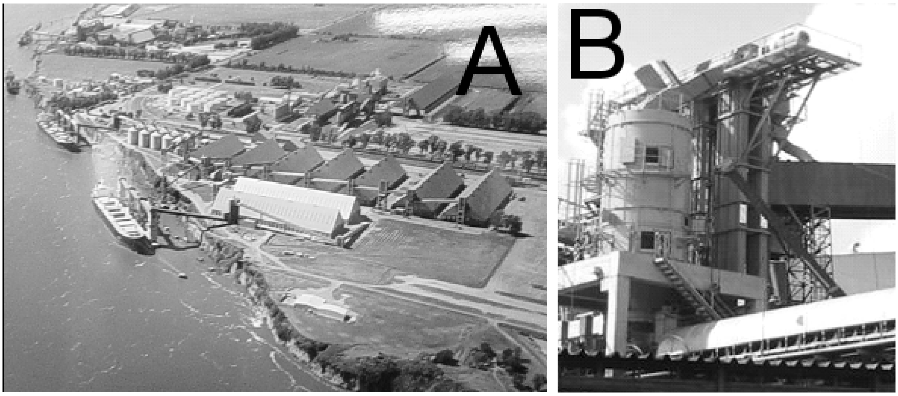

Figure 7 A. Facility with extended tunnel conveyor lay-outs with no elevators, B. Filter bag houses.

6. Conclusions

Grain dust is explosive, and by far the biggest risk in the grain storage and processing industries is a dust explosion. Wherever grains are handled, there is a potential to generate dust and consequently, the risk of explosion. The most important preventive practices to limit the dangers of dust explosion are to avoid the formation of explosive air-dust concentrations in confined spaces and limit any source of ignition that could ignite a primary explosion, thereby minimizing the risk of expansion that would generate secondary explosions.

Training and education must be intensive and essential. Facilities not properly designed and if poorly maintained, can be the source of expensive consequences. I hope this article will help prevent future explosions by both alerting and reminding the industry of the need to reinforce safety issues.