Grain Dust Explosions: A Report from South America

Roberto D. Hajnal

In South America, grain elevators have not been exempt from dust explosions. Between 2001 and 2002 there were three major dust explosions, Toepfer, Puerto San Martin (Argentina), ACA San Lorenzo (Argentina) and Coinbra, Paranaguá (Brazil), with both great loss of life and materials.

Since then, 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 cause complete material damage.

In April 2002, the ACA Terminal (Asociación de Cooperativas Argentina) exploded in San Lorenzo, Santa Fe province, Argentina. The result was tragic: three people were killed, 19 injured, and there was total destruction of the main infrastructure, resulting in millions of dollars worth of lost materials.

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 oilseed crushing plant is located, with a production capacity of 12,000 metric tons 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 Aires 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 10 deaths.

But the worst explosion was the tremendous tragedy that occurred in 1985 at the silos of la Junta Nacionalde Granos, in Bahía Blanca, an ocean terminal, killing 22 and injuring more than 10 people.

Two scenes (above and far right) from the ACA San Lorenzo Terminal explosion in Argentina in 2002. This explosion killed three people and injured nineteen.

The Toepfer Puerto San Martín explosion in Santa Fe, Argentina in 2001 started with a primary explosion that caused chain-reaction second and third explosions.

The 2001 Coinbra Paranaguá Terminal explosion in Paraná, Brazil, blew five-ton pieces of concrete 300 meters, and grain continued to burn for nearly three weeks.

The Toepfer Puerto San Martín Explosion, Argentina, October 2001

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

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 horizontal silo, where the workers were. The horizontal silo was empty but two workers inside the tunnel were killed instantly and a third, working on the floor of the flat silo, was killed as the concrete tunnel roof blew up. A chain reaction of ever-increasing intensity had been set in motion that culminated with a third explosion that impacted the reception area (about 300 meters 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 has to be present. Without an electrical spark or an overheated bearing, and with no dust in suspension and nothing moving, an explosion seems impossible!

Experts think that the Toepfer explosion was due to hexane gas rather than grain dust. Since rebuilding hexane monitors have been installed in the tunnels which detected 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.

The Coinbra Paranaguá Explosion, Brazil, November 2001

Again the explosion occurred at midday, while loading corn 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 concrete that hit their facility during the explosion.

The explosion started in the shipping bucket elevators that 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 placed into suspension in the air, thereby contributing to a series of subsequent explosions. The secondary explosion was so strong that all resistant structures collapsed, even rail cars were turned like toys, big pieces of concrete that weighed over five tons were blown 300 meters away, and the steel shipping tower was turned down to earth. The destruction was followed by fire, which ignited the grain and continued burning for nearly three weeks.

U.S. Agricultural Dust Explosions Report for 2004

There were six dust explosions reported in the U.S. in 2004 according to Robert W. Schoeff, professor emeritus, Kansas State University, and Mavis Rogers, FGIS-USDA (Federal Grain Inspection Service). This compares to 7 in 2003 and a ten-year average of 10.1 explosions. There were no fatalities and only four injured.

The location of the primary explosion was identified in 4 of the 6 incidents as the bucket elevator and one each in a sifter and mixer. The probable ignition source was identified in two cases as bearing failure and static electricity, and one case each of metal sparks and fire. Fuel sources were identified as corn (3) and one each wheat starch, corn gluten, and cellulose. Dust explosions occurred in five different states: Iowa (2), Kansas, Minnesota, North Carolina, and Ohio according to the report.

This annual report is based on a variety of news sources and the voluntary cooperation of facility management as FGIS seeks to identify agricultural dust explosions that have occurred and what the causes might have been. The data is compiled as a service to the grain storage and processing and allied industries, trade associations, insurance companies, and government agencies. The report is also subject to revision as additional information is received.

The ACA San Lorenzo explosion, Argentina, April 2002

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 soybeans onto a ship on a dry and sunny autumn day. Again, luckily, the main personnel were out for lunch. Even so, the explosion left three dead, 19 injured, and caused massive destruction of the terminal.

They had been loading a ship that was receiving simultaneously from three spots:
a) from the horizontal silo
b) directly from trucks through the receiving pits
c) directly from railcars

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 head house tower that supported the shipping bucket elevators. This head house was built on a concrete structure, but with no walls, that helped to stop and dissipate the destructive explosion 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 below-surface tunnel was in the flat storage, connected to another 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 silos, and from the railcar reception area arriving at 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 three days later in the shipping bucket elevator pit, 15 meters below ground level, where the shipping tower stands.

ACA Facility Reconstruction

The former idea of extended lay-outs with no bucket elevators has changed. It is now believed that the installation of bucket elevators will prevent the transmission of any primary explosion to the rest of the facility. It is interesting to observe the thinking behind the reconstruction. The design is supported by three main axes:

1. Minimizing explosion risks, by:
1.1. 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 silo.
1.2. Confining the risks to certain sectors by installing the bucket elevators at the end of every tunnel, eliminating connections between tunnels, avoiding the propagation of the explosion.
1.3. All the mechanical handling is now fitted with hazard monitors, controlling speed, belt misalignment, belt slip, plugging and maximum belt extension, with emergency stop.
1.4. The elevator towers are open and made of steel. Elevator pits are also open.
2. Reduction of Environmental Pollution
2.1. Replacing cyclones with low-pressure filters (bag houses).
2.2. Thirty three big aspiration systems with filters (bag houses), that collect the dust emitted during operations, in different sections of the facility.
2.3. Installation of a white mineral oil application system for dust-emission control.
2.4. 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.
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 tph at 4.00 m/s. By comparison, in the new facility the same conveyors run at a capacity of 1,200 tph at 3.00 m/s.

How the Grain Industry Responded

In South America there is still no specific legislation to prevent dust explosion hazards. However, in Argentina, due to the frequency of recent explosions, there is now greater awareness within the industry on the hazards of grain-dust explosions. Our vegetable oil industry is both very strong and conscientious, so 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 upgraded. The installation of adequate electronic hazard monitors is adding higher levels of security. Furthermore, training and education are intensive, through the oil industry professional association ASAGA and APOSGRAN (similar to GEAPS), which conducts courses and seminars on dust explosion risks and prevention, training both firemen and operational personnel. APOSGRAN is also translating GEAPS videos and guidebooks dedicated to preventing grain dust explosions.

This article was a presentation at The Grain Elevator & Processing Society's (GEAPS) 2004 international technical conference and exhibition (the Exchange) in Minneapolis, Minnesota. Roberto Hajnal is dedicated to bulk handling technologies, as an equipment and engineering supplier, based in Buenos Aires, Argentina, and also serving Brazil and Uruguay. He is Director of 4B Sudamerica SA, President of Juan O. Hajnal SA, and a Board Member of APOSGRAN (Asociación Argentina Poscosecha de Granos), a GEAPS-type organization. You can contact him at roberto@hajnal.com.ar or visit his website at www.hajnal.com.ar. ■