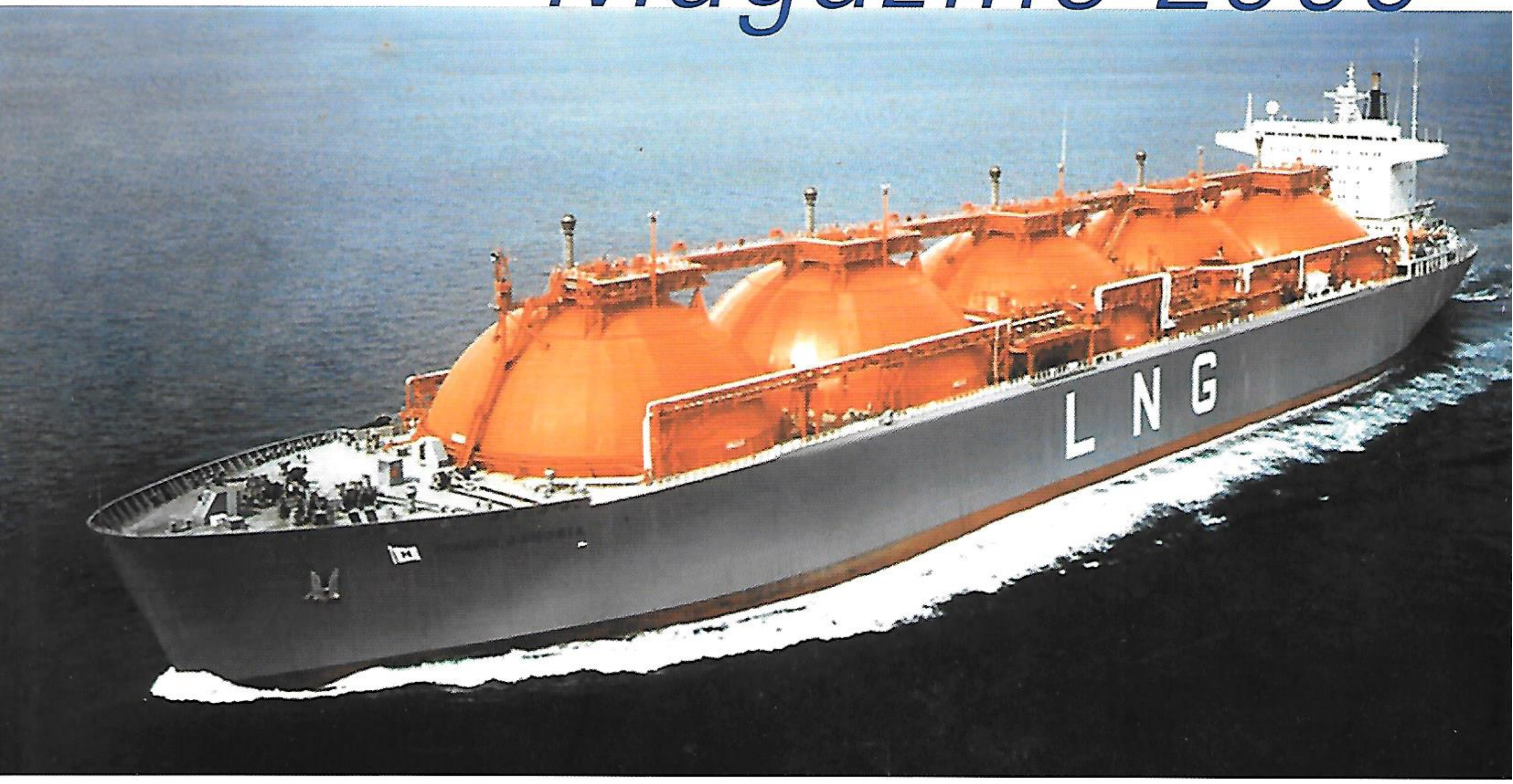
for the installers and operators of explosion protected electrical installations

Magazine 2006



STAHL

Dust explosion protection in Brazil

by Estellito Rangel Junior and Rainer Nägle

Figure 1: Result of a dust explosion with extreme destruction (credit: Cris Coutinho)

The protection against gas explosions is and always has been a major issue in Brazil and is well established in the national standards since many years. The pharmaceutical, chemical and petrochemical industry as well as the oil & gas industry is well aware of the potential risks and is investing in the installation in hazardous areas the necessary explosion protected electrical equipment.

Beside the well known international players like for example BAYER, BASF and DOW also the state-owned national oil company PETROBRAS and the largest privately-owned Latin-American petrochemical group BRASKEM are looking very careful to protect their plants against the risks of gas explosions.

Figure 2: Warehouse of the company Coinbra in November 2001 before explosion accident (credit: Cris Coutinho)

But what about the protection against the hazards of dust explosions? To answer this question we first should have a glance on the importance of the industries with a potential risk of gas explosions and compare them with those industries with a potential risk of dust explosions.

PETROBRAS with an oil production of 1.8 million barrels per day ranks No. 7 of the worlds free tradeable oil & gas companies. This production is equivalent to about 2 % of the Brazilian Gross Domestical Product. In comparison to that figure, agriculture accounts for 10 % of Brazil's GDP. Here at the forefront the production of grain crops, with over 110 million tonnes/year and soybean yielding 50 million tonnes. Brazil is a pioneer and leader in the manufacture of short-fiber timber cellulose and it stands for 25 % of the global exports of raw cane and refined sugar and for 50 % of the planet's orange juice.

Not to forget the importend branch – the mining industry, where Companhia Vale do Rio Doce (CVRD) is the largest diversified mining Company in the Americas, world leader in the iron ore and pellet market and the second largest global producer of manganese and iron alloys.

Although many of the above mentioned agricultural and mining production processes are not affected by the risk of a potential dust explosion (e.g. mostly the cultivation and processing of soybeans), there is still a high percentage of processes where a risk evaluation has to be conducted.

Especially the transport and the storage of grain leads to hazardous areas with the possible presence of combustible dust atmospheres.

The risks of fire and explosion in silos, in practice are present in all stages of grain processes, since the reception of raw material, passing through the belt conveyors, until the storage in silos. The main component of this risky formula is a possible high concentration of organic dust in the typical confined spaces of such locations, as underground elevators and tunnels.

Dust explosions in Brazil

In recent years we were noticed about fires and explosions in grain storage installations that resulted in losses of millions of dollars and also with fatal victims, in the United States, France, Spain and also in Brazil. Some occurrences in Brazil were:

- The explosion of the C-2 cell, of the vertical silo at Paranaguá Port, Paraná state, on January 1992, when two workers died and five had been injured [1]. The most probable cause would have been the combustion of dust of barley – that was stored there – during a cleaning operation on the tenth floor of the silo (it had 13 floors, 55 meters height and a total capacity of 100 thousand tons).
- The explosion of a warehouse of the international company Coinbra, responsible for a grain storage in the so called ›Exportation Corridor‹ of Paranaguá Port, on November 2001, that injured eighteen people [2]. The explosion was so strong that pieces of roof zinc tiles had been hurled up to one thousand meters of distance, and concrete structures with 300 kilograms also had been found far away. Beyond the destruction of the deposit, transport companies, whose trucks were on the street waiting to unload, suspended all operations of the ›Exportation Corridor‹ for a week.
- An explosion destroyed three soy driers, with 40 tons each, of the Bunge Food Company in Rio Grande do Sul state, on December 2003, with no victims [3].
- The explosion of a rice dryer of 30 tons in Mato Grosso state, on February 2005, with no victims. [4]

➔

Figure 3: Warehouse of the company Coinbra after the dust explosion (credit: Cris Coutinho)

The dust behavior

The majority of grains are susceptible to develop a fast combustion process when the particles' size is small enough. Under confinement, this combustion will reach explosive conditions that produce hot gases, which in turn generate an increased pressure inside the vessel.

As in the case of explosions originated by gas atmospheres, to have a dust explosion, a source of ignition and an explosive atmosphere are necessary to be present at the same time. Sparks and hot surfaces produced by electrical equipment (motors, control stations, switches, etc.), are the most common sources of ignition found in industrial installations with explosive atmospheres [5].

It is important to say that the behavior of combustible dusts is completely different from gases. While flammable gases are spread out easily in air, searching for a homogeneous concentration, the dust particles tend to settle down, producing accumulation in layers. The dust particles can remain in suspension for some time, depending on its density and particles' size, and can also travel from the point that they were released until other places of the plant. They can leak from one given process equipment and go into other components, as example, an electrical terminal box.

Dust can accumulate on the floor, on piping, on equipment surfaces, on cable trays, on electrical motors shafts, etc.

The dust particles can come into contact with sources of ignition when accumulated in layers, when forming a cloud, when in suspension, and also during ›normal‹ operation (for example, cleaning operations using brooms). If a dust explosive cloud comes into contact with a powerful enough source of ignition (some millijoules), an initial ignition will be produced. This would be the primary explosion, generally with subsonic speed (also known as ›deflagration‹), which generates a considerable volume of hot gases that in turn develops a pressure wave. After this, dust that has settled nearby easily becomes suspended, forming a new dust cloud in front of the first flash. The initial flame now becomes a new source of ignition for the newly formed cloud (flammable mixture). The process thus repeats itself, quickly producing a sequence of new secondary explosions, with increased energies that potentially cause the destruction of the entire plant [6].

Statistic data

Recent statistics [7] show that in 129 agricultural dust explosions occurred in the USA between 1988 and 1997, the probable cause of ignition was identified in 70 % of the cases, following the distribution shown in Figure 4. Figure 5 presents the location of primary accidents, identified in 91 % of the 129 cases studied.

Characteristics of dust explosions

To produce a dust explosion, the following conditions must happen simultaneously:

- Combustible dust in suspension;
- Dust concentration in suspension must be above its lower explosion limit (LEL – usually in the range from 20 to 60 g/m³);
- Dust must have particles of adequate size (in general diameters between 0.02 mm and 0.4 mm);
- Air (oxygen) present;
- Source of ignition with adequate power.

In general, it can be said that it is more difficult to initiate a dust explosion than it is to initiate an explosion of flammable gas or vapor atmosphere because the necessary energy to ignite dust is higher (magnitude of mJ) than that which is necessary to ignite gases (magnitude of µJ).

Brazilian standards

The Brazilian Committee of Electricity, Electronics, Lighting and Telecommunications (COBEI) is responsible for developing the Brazilian standards (issued by ABNT, the National normative organization) for electrical installations in potentially explosive atmospheres.

Brazil is a ›P‹ (Participating) member in IEC TC-31, and its electrical standards are harmonized with the IEC standards. The Brazilian standards for electrical installations in combustible dust environments are scheduled to be issued on 2006. The main users of such standards are pharmaceutical companies, food processing companies and chemical industries, of which the majority are foreign operators. As Brazilian standards have not yet been issued, the common practice of the Brazilian branches of these companies is to use foreign standards for their premises, usually the standards recommended by the company's headquarters located abroad.

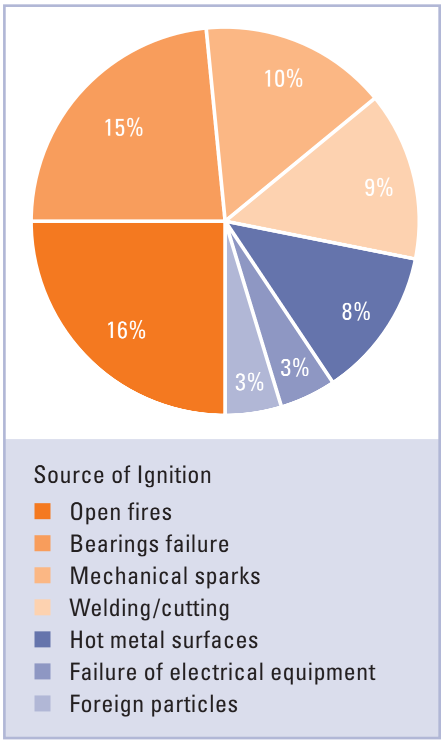
Regarding Brazilian companies that have locations classified as Zone 21 and 22, it is important to say that the Brazilian standards about electrical installations on potentially dust atmospheres are not available yet. Due to this, these companies used to build their electrical installations with IEC standards, but it was noticed that in many cases, American standards are also used.

It is expected that after the Brazilian standards are issued, all these companies will start updating their classified area documents, in accordance to the new Labor Ministry Regulation – NR-10 – issued on December 2004, that increased the legal requirements for electrical safety in the workplace.

In Brazil, the notified bodies do not perform yet the conformity certificates for electrical equipment for use in dust atmospheres, which implies that customers need to use imported electrical equipment to perform their installations.

Table 1 shows the scheduled plan for issuing the Brazilian standards regarding electrical installations for combustible dust atmospheres. ➔

Figure 4: Probable causes of ignition in explosions in agricultural installations (USA 1988 – 1997)



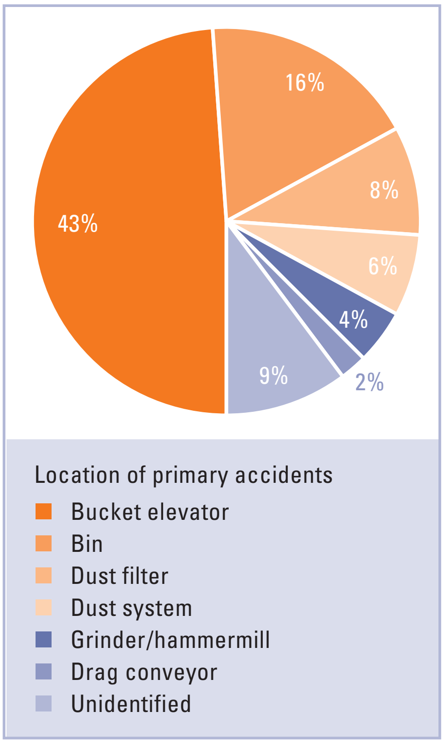


Figure 5: Location of primary accidents (USA 1988 – 1997)

Brazilian laws

An important measure for the safety of installations and workers was the emission on May 2005, by the Ministry of Labor and Jobs, of the Regulatory Norm 31 (NR-31), which established legal requirements to ensure safety and health at work in Agriculture, Cattle, Forest exploration, and Fishery. Amongst its requirements, some were especially issued to avoid dust explosions at silos installations, as example:

- **31.14.9:** The risks of spontaneous combustion and explosions at silos must be foreseen and controlled during design, operation and maintenance;
- **31.14.1:** The elevators and feeding systems of silos must be designed and operated in a way to prevent dust accumulation, in special at places where the generation of sparks by static electricity is possible;
- **31.14.12:** All electric installations and lighting fixtures inside silos must be adequate to the area classification.

Conclusions

Despite their ›harmless appearance‹, combustible dusts have a huge destructive power. Safety needs to be a core value for operators, which implies that design, installation and maintenance on these installations, need to be performed strictly following the technical and legal requirements, with trained personnel.

A regular inspection program [8] is an important tool to prevent undesirable accidents and losses, bearing in mind that employees are the most important factor in hazard reduction.

With the issuing of the new Brazilian technical standards for combustible dusts based on IEC standards, planned to start in 2006, more and more Brazilian companies will be able to update their area classification documents, identifying the areas with potential risks of combustible dusts. Although the classification of hazardous areas has its economical limitations, it is expected that even small grain mill companies will benefit from Brazilian standards, because they will be able to train their technicians in their own language, avoiding an over classification of their hazardous areas, especially because using imported equipment will increase the installation costs.

Table 1: Scheduled plan for Brazilian Ex-standards for dusts

IEC Standard number	ABNT number	Foreseen date of issue
IEC 61.241-0	NBR IEC 61.241-0	2006
IEC 61.241-1	NBR IEC 61.241-1	2006
IEC 61.241-14	NBR IEC 61.241-14	2006
IEC 61.241-10	NBR IEC 61.241-10	2007
IEC 61.241-20-2	NBR IEC 61.241-20-2	2007
IEC 61.241-20-3	NBR IEC 61.241-20-3	2007

Literature

[1] Aedata News ›Explosion at Paranaguá Port kills 2 people‹. In: Estado de São Paulo Newspaper website at http://www.estadao.com.br/ext/diariodopassadoso/20020124/000120966.htm. January 24th, 1992.

[2] FADEL, Evandro ›Explosion in silo cause injury to 18 people in Paranaguá‹. In: Estado de São Paulo Newspaper website at http://www.estado.estadao.com.br/editorias/2001/11/17/cid016.html. November 17th 2001.

[3] Correio do Povo Newspaper – ›Fire destroys 3 soy dryers‹. In December 6th 2003, Brazil.

[4] Sonoticias website – ›Rice dryer and tonnes of rice destroyed by fire‹. In: http://www.sonoticias.com.br/mostra.php?id=93272 . Nova Mutum, Brazil.

[5] RANGEL Jr, Estellito. – Explosion prevention in oil industries based upon electrical installations requirements. In: RIO OIL & GAS CONFERENCE, 2000, Rio de Janeiro, Brazil.

[6] ECKHOFF, R.K. – Dust explosions in the process industries. 2nd Edition, Butterworth Heinemann, 1997, ISBN: 0 75063 270 4.

[7] SCHOEFF, R.W. - Case study of dust explosion at DeBruce Grain Co. terminal elevator, Haesville, Kansas. In: 3rd WORLDWIDE SEMINAR ON THE EXPLOSION PHENOMENON AND ON THE APPLICATION OF EXPLOSION PROTECTION TECHNIQUES IN PRACTICE, 1999, Ghent, Belgium.

[8] RANGEL Jr, Estellito. – Electrical installations in explosive atmospheres: Inspection and maintenance are basic activities for safety. In: I IEEE ESW Brazil - INTERNATIONAL SEMINAR OF ELECTRICAL SAFETY IN THE WORKPLACE, 2003, Guararema, Brazil.