Dust Explosion Risk Protection

Effective Protection or Cost Driven Safety?

Operators of a system that has been running safely for many years are sometimes ruluctant to change that system. However, reagrding safety and, more importantly, upgrading of their safety systems, they should not be complacent. Especially with regard to explosion protection, it is necessary that the protective measures be examined regularly and be adapted to the latest state of technology. This does not always result in higher costs. On the contrary, this frequently involves a process improvement at minimal costs.

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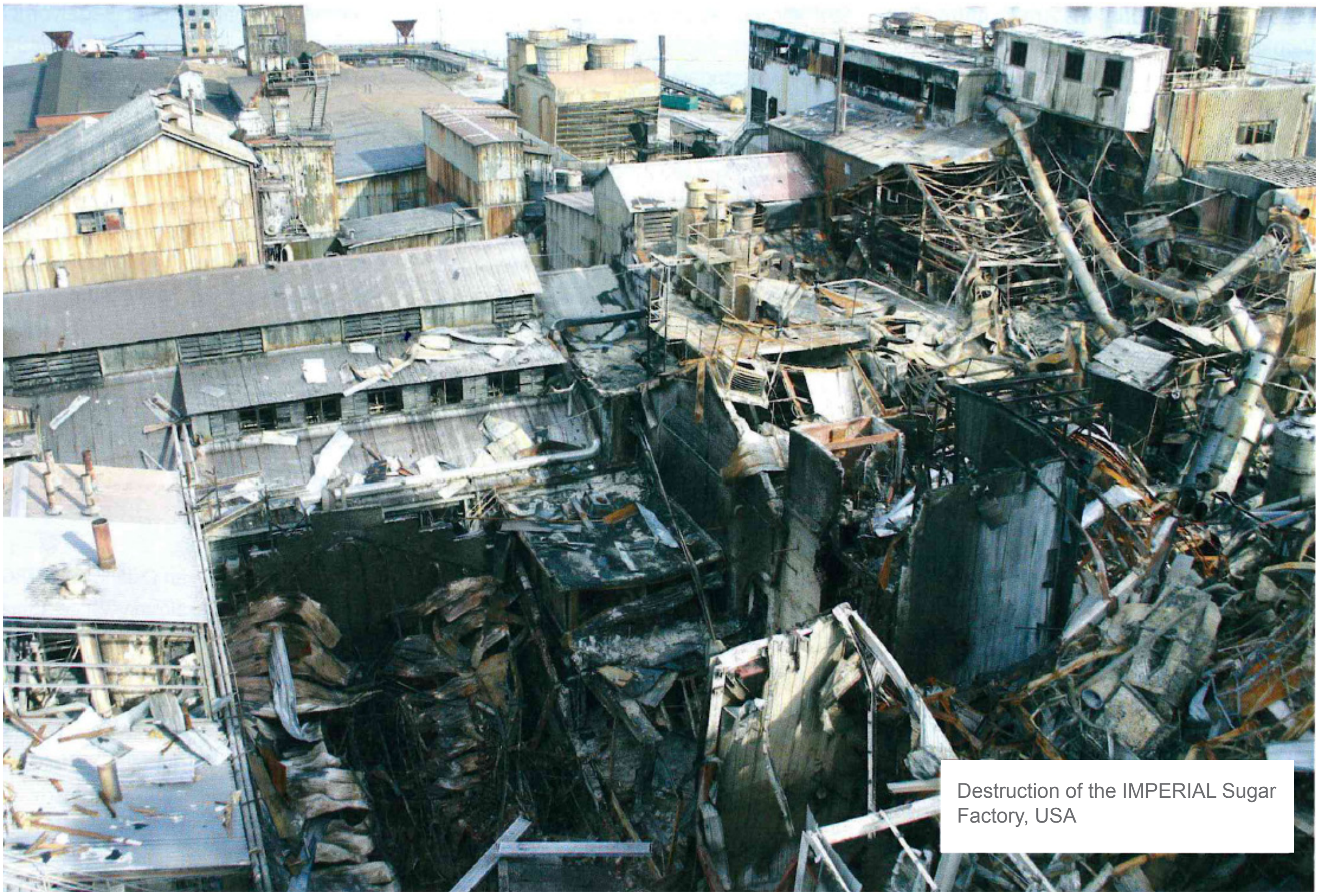

Destruction of the IMPERIAL Sugar Factory, USA

One encounters plant operators throughout the world who believe the powder production system they have been operating successfully for many years is sufficiently safe, even without additional measures. After all, they can state that the operation has been running for many years without any notable failures or risk events. Reference is frequently made to „much more dangerous" operating conditions in the liquid or gas processing chemical industry. This is the reason the Europeans, with their tendency for firmly-stated regulation, are sometimes considered to be over-zealous. But protection of life should never be considered as an escessive cost. Domestic plant designers are also under considerable cost pressure when they must quote outside their home market, into other jurisdictions which have considerably lower safety standards. Explosion protection is expensive. Or is it?

The preamble to the ATEX directive however, clearly points out our joint responsibility:

The Member States have the task of ensuring safety and of protecting the health of persons and domestic animals, if necessary, and the safety of goods in their sovereign territory. [1] Naturally, this obligation for plant designers and internationally active producers can and must not be limited just to the European area. The directive was also implemented with extreme hesitation initially in many companies, even in Europe. The need for explanations frequently appeared to be unreasonably high, as did the administrative costs. Proven procedural methods

Bulk goods - tip !

Where are the sources of ignition located?

Hot spots, hot surfaces, static electricity („charging"), mechanically generated sparks or light arcs are seen as possible sources of ignition. In Analysis 3 by H. Beck in 2002, an evaluation was performed on the cause of the sources of ignition for dust explosions.

- 32.7% mechanical sparks / hot surfaces
- 12.7% hot spots
- 8.5% electrostatic discharges

had to be scrutinized and clearly documented. It became obvious that many of the old methods and operating procedures were no longer appropriate, in view of the ATEX guideline and developments by equipment manufacturers. Therefore, these needed to be revised. In many discussions, the responsible employees in a production plant pointed out that production had been safe so far and that there had not been any relevant incidents. These comments had to be respected, but no plant, in whatever industry or process, can remain static in the face of changing standards and rapidly improving product development.

Bitter Realisation

A safety system failure, leading to a bitter realisation of the need for changes, is illustrated below. It is one of a number of similar events. Explosion can and do kill. Frequently it is only possible to see how important safeguarding human life can be in the aftermath of serious explosions. A destructive explosion occurred in a sugar factory in Port Wentworth, Georgia, USA, on 7 February 2008 at 7:15 a.m. This plant had been in existance since 1917. In total, 14 persons died, another 36 persons were injured, many seriously. The four-storey packaging hall, the bulk loading area for HGVs and railcars, the 32 metre high silos and major parts of the refinery were completely destroyed during the explosion.
The responsible authority CSB [2] published its final examination report on 24 September 2009. The report found that the massive destruction was attributed to an initial explosion in the transportation system beneath succession of other secondary explosions, in many other parts of the system. The conveyor ran in an enclosed housing, but released sufficient material into the surroundings to allow a considerable layer of sugar dust to accumulate in the surrounding working area. This meant that a critical density of a dust-air mixture formed inside the conveyor's metal housing. This concentration exploded, due to an „unknown source of ignition". Immediately following the initial explosion, the dust that had settled on the surfaces and machines in the factory building were whirled up by the pressure wave. This caused another explosive atmosphere to be developed, and its explosion continued through the respective neighbouring plant parts. It was noted that the individual areas of the factory were inadequately sectioned off from each other, in terms of structure. Poor maintenance and cleaning of the plant was one of the focal points of the investigations, as the dust deposits had a major effect on the subsequent explosions and fires. There was no appropriate dust-removal system in existence. As the material was transported using a multitude of inadequately serviced bucket conveyors, belt conveyors and conveying troughs as well as augers to the individual packaging systems, the corresponding leaks ensured there was a permanently emerging accumulation of sugar dust in the factory buildings. Even though no notable incident had occurred during a period of 90 years, the risk had developed and it was easy to see that a sense of confidence in the safety systems had set it. Each of the company's factories was supervised by a specially trained employee (Safety and Security Manager). The required observation of sources of danger is easy to see if one uses this example. But despite the confidence of these safety managers, the explosion still occurred, death and injury, and the enormous cost to the company were the result.

Primary Explosion Protection

Initially, every plant operator must ensure that the formation of a dangerous explosive atmosphere is prevented or restricted. (Avoidance of explosive atmosphere). An explosion or deflagration is only possible at all due to the concentration of a suitable quantity of dust in the air. If this mixture ratio is effectively modified using suitable measures, by either reducing the oxygen ratio, e.g. by increasing the nitrogen content in the system, or by mechanically limiting the dust ratio, the explosive atmosphere can be avoided. Technically modified surface structures containing the medium can also contribute towards clearly lowering the flammability of the dust. In the Port Wentworth case, the sugar factory displayed considerable deficits in regard of safety. Open or inadequately covered transportation, poor temperature monitoring and inadequate maintainance and cleaning, enabled material to exit and the formation of the ignitable air/dust mixture.

Secondary Explosion Protection

If an ignitable concentration cannot be safely prevented or permanently prevented, it is necessary to effectively prevent the ignition of the explosive atmosphere (effectively eliminate sources of ignition). Since electrical engineering, at least in the European states, has had a high significance for several decades, ignition due to poorly designed devices (controllers, position feedback systems, pressure, temperature and fill level sensors, etc.) is rather rare. Experience gained in the mining industry and chemical plants had already resulted in suitable protective measures more than one hundred years ago. The dissipation of possibly-encountered electrostatic chargers has also been included in the electrical engineers' rules and regulations. Pipework, vessels, mixers and filtration systems were and are incorporated in the potential equalisation. However, until recently, valves and fittings received less consideration. While the elastomer sealing faces on ball valves, gate valves and non-return valves are relatively small, the medium directed through on shut-off valves, control valves, butterfly and pinch valves hits large surfaces, with high leakage resistance. The danger of electrostatic charging should not be ignored here and the valves/fittings must be equipped with proven electrical and mechanical properties, by using suitable material combinations. Mechanically generated sparks, which are a dangerous ignition source, frequently elude the eyes of the responsible operator. The sugar industry, in particular, finds itself confronted with a number of metallic contaminants. If these find their way into a pressure or suction feed pipe, this can very well cause sparks due to their high transport speed. A poorly designed washer/ shaft combination in a shut-off valve can blow out in the event of an explosion, generating ignition sparks in its wake. In this case, careful examination by the manufacturer, the designated body and the responsible plant operator is essential.

Fig. 3: The *clocked airlock* can generally be integrated in existing systems because of its lightweight and compact shape, without having to install complicated support structures or additional electrical supply lines.

Fig. 2: Prototype tested shut-off valve with potential equalisation
Successfully completed prototype testing, by the manufacturer, is the suitable procedure to safeguard the operator and to support him with the corresponding documentation. In the case of the explosion in Port Wentworth, serious defects were discovered with regard to the construction and verification of suitability. The latter meant that the responsible managers had to be held personally accountable.

Tertiary Explosion Protection

The role of explosion protection is to suppress the effects of an occurring explosion, to below a threshold value, where there is no appreciable risk. This includes providing both a suitable spatial separation of the plant parts and isolating the occurrence within the conveying lines. Regardless of the method of transport (gravity, pneumatic or mechanical conveying), appropriate transfer points must be provided. Certified clocked airlocks are available for this. This relatively inexpensive transfer unit essentially consists of two fittings, connected by a piece of pipe or conical container, each of which must be individually certified as ignition/ flame-resistant and puncture-resistant. First, the inlet flap is opened allowing the medium to flow into the chamber. The outlet flap must remain force-locked until the upper valve is safely closed again. Only then is the medium transferred to the following production process by the lower valve/fitting, and the discharge cycle begins again.

The interlocking procedure is controlled by certified electrical safety components. It thus avoids mechanical interference sources and wear-related inaccuracies in the position monitor. The entire subassembly is considered as one unit for explosion decoupling and is certified accordingly. Because of the use of standardised valve/ fittings, no elevated maintenance and servicing costs are produced, Normally, only the elastomer seals are replaced when they are worn. Thus, the clocked airlock is not only of interest from the aspect of investment costs, but also with regard to the operational costs. In addition, the clocked airlock can generally be integrated easily into existing systems because of its lightweight and compact shape, without having to install complicated support structures or additional electrical supply lines. The ATEX guidelines are valid in the Member States and must be considered both by planners, system designers and operators. They are also an important component for fundamental risk assessment and effective measures in other jurisdictions, whose rules and regulations have a different approach to the protection of health and life of humans. Certified valves/fittings and explosion decoupling systems ensure that maximum security can be ensured, even from the aspects of business management.

[1] Guideline 2014/34/EU of the European Parliament and Council- dated February, 26th 2014 (revised version)
[2] U.S. Chemical Safety and Hazard Investigation Board

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