Dust: hidden dangers

Keith Plumb looks back at dust explosions, and wonders if industry has learned its lessons

RECENTLY I did some research into dust explosions and was surprised to learn how little things have moved on over the years. One of the first recorded dust explosions was in a flour warehouse in Turin in 1795 that injured two boys but did not kill anyone. As the scale of human industrial processes has grown, so – sadly – has the size of the dust explosions.

In 1878 the Washburn 'A' Mill, then the largest flour mill in the US, exploded. The blast claimed 18 lives and destroyed a large amount of the surrounding area – pictured right is a remarkable image taken at the time. This explosion led to reforms in the milling industry to reduce the dust in air during milling and to improve housekeeping.

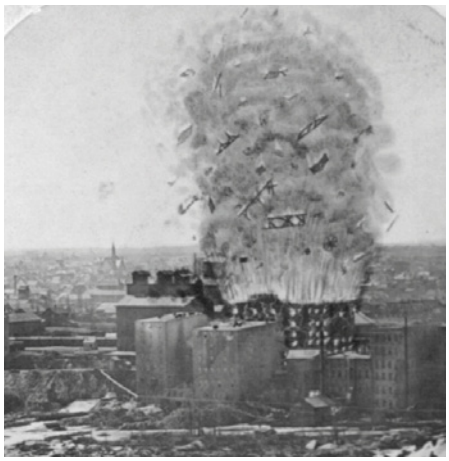
In view of the lessons apparently learned you might have expected that matters would have improved, but this is not so. For example in the US, despite a major initiative by the Occupational Safety and Health Administration (OSHA) to reduce the number of explosions in grain storage facilities there were a reported 17 combustible dust fires and explosions at grain facilities between February 2008 and August 2008, 35% of which were explosions[1].

Grain is, of course, not the only source of dust explosions. On 7 February 2008 an explosion at the Imperial Sugar Company in Port Wentworth Georgia, US killed 14 people and injured 36. There was a series of explosions, the first of which started in an enclosed steel belt conveyor under the sugar silos. The recently-installed covers allowed explosive concentrations of sugar dust to accumulate. A secondary explosion arose due to sugar dust accumulated on floors and elevated flat surfaces, and this explosion propagated through large parts of the site. This shows how new risks can be introduced when making modifications, and that poor housekeeping is still a problem 130 years later.

Grain dust and sugar dust are but two of the many dusts that can lead to dust explosions, and a wide range of fine materials including many organic materials, inorganic materials and metals powders will explode. The Berufsgenossenschafliches Institut für Arbeitssicherheit (BIA) report 13/97 is a good source of information on the explosive properties of dusts[2].

an alarming growth rate

The US Chemical Safety and Hazard Investigation Board (CSB)'s November 2006 investigation report[3] makes interesting reading. It highlights the fact that the number of incidents in the US has risen since 1980 and numbers of injuries and fatalities have grown rather alarmingly (see Figure 1). The report suggests that this may be due to under-reporting in earlier years (which may be true), but it could also be due to increases in industrial activity. Some US commentators suggest that the problem may lie in OSHA's regulatory approach.



Explosion of the Washburn A Mill, Minneapolis [Photographer: William H Jacoby (1841–1906)]

There are no comparable up-to-date statistics for the UK and Europe. However, the Health and Safety Executive (HSE) data presented by Lunn[4] for 1979–1988 says there were 303 fires and explosions over the nine-year period. Of these, 136 were explosions, which gives an average of 15 explosions per year, and is comparable to the US data.

Zeeuwen[5], in 1997, said that the data available then did not indicate a trend, and the increased use of dust extraction to protect workers from dust was probably causing a rise in explosions, whilst increasing awareness of dust explosions was tending to push in the opposite direction.

regulations and standards

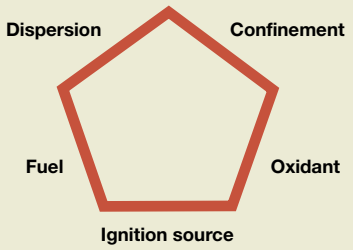
Recently, much good practice from Europe and elsewhere on equipment use in explosive atmospheres has been incorporated into IEC standards. This has led to the IEC 60079 series of standards covering such subjects as hazardous area classification, the design and testing of electrical equipment and the selection of electrical equipment. These IEC standards are now recognised in most countries including the US and Canada.

However, the statistics suggest that whilst the IEC standards are to be welcomed, perhaps the focus should be elsewhere. Statistics for dust explosions in Germany are

How and why dust explosions happen

Dust explosions occur when all five requirements of the 'explosion pentagon' are met. Two additional items are required beyond the normal fire triangle: dispersion and confinement. Layers of dust will burn but will not explode and without some form of confinement, an explosion will not occur.

The CSB report gives the key reasons why dust explosions occur. Poor housekeeping is a major problem because a small primary explosion causes dust on floors and elevated flat surfaces to be dispersed, the primary explosion acts as the ignition source for a much larger secondary explosion and the buildings themselves provide the necessary confinement. This is what happened in the Imperial Sugar Company incident.



Protection and mitigation

Step 1: Check if you are handling any combustible dusts.

a) Check the material safety data sheet and the BIA report[2] 13/97.

b) If you are in any doubt have the material tested using a specialist testing company.

Step 2: Review the process to see if it is possible to modify the process so that the combustible dust is not used.

Step 3: Eliminate as many ignition sources as possible including electrical equipment, mechanical sparks, friction and static electricity.

Step 4: If a risk assessment shows that it is necessary, provide further protection measures such as inert gas blanketing, explosion venting or explosion suppression. Alternatively use equipment that will withstand the maximum explosion pressure.

Step 5: If a risk assessment shows that it is necessary, provide measures to mitigate the consequences of the explosion by reducing the inventory of material, improving housekeeping, reducing the dispersion of dust, eliminating/reducing confinement and providing means to prevent an explosion spreading.

For more details of the approach to protection and mitigation methods see reference 6.

summarised in Figure 2. These data show that electrical equipment is a minor source of ignition and that other sources such as mechanical sparks, friction, static electricity and glowing clumps are of much greater importance. Data presented by Lunn for the UK gives a very similar picture.

In Europe the ATEX directive requires non-electrical equipment to be certified and this should be having an impact on the sources of ignition shown in the data from BIA. Unfortunately the standards for non-electrical equipment do not have any IEC equivalents.

believe it or not

The 2006 CSB report[3] has a number of important, alarming findings. The report is based on 281 combustible dusts fires and explosions found many common factors:

- workers and managers were often unaware of dust explosion hazards, or did not know how serious the hazard was;
- facility management failed to conform to National Fire Protection Association (NFPA) standards that would have prevented or reduced the effects of the explosions;
- facilities contained unsafe accumulations of combustible dust and housekeeping was inadequate;
- procedures and training to eliminate or control combustible dust hazards were inadequate;
- warning events were accepted as normal and their causes were not resolved;
- dust collectors were inadequately designed or maintained to minimise explosions;
- process changes were made without adequately reviewing them for the introduction of new potential hazards; and

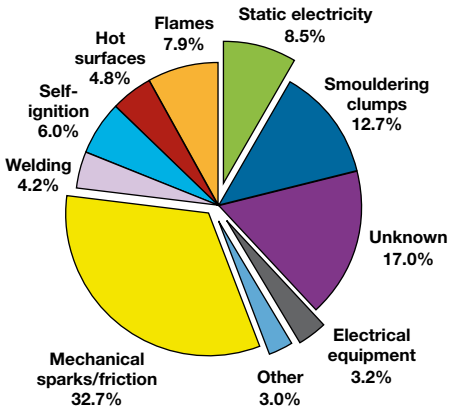


Figure 2: Sources of ignitions for dust explosions [Source: BIA Report 11/97]

- government enforcement officials, insurance underwriters, and health and safety professionals inspecting the facilities failed to identify dust explosion hazards.

One other observation in this report was that 41% of material data safety sheets (MSDS) relating to combustible dusts that the CSB surveyed did not warn users about explosion hazards. I would concur with this finding.

taking stock

Are you doing enough to ensure that your facilities are adequately protected or that the project you're working on won't introduce dust explosions hazards? Are you using the up-to-date standards? Are you giving adequate consideration to all of the potential sources of ignition? Is your housekeeping up to scratch? Do you have appropriate equipment to prevent or reduce the effects of dust explosions? If not, then it is time to do more. **tce**

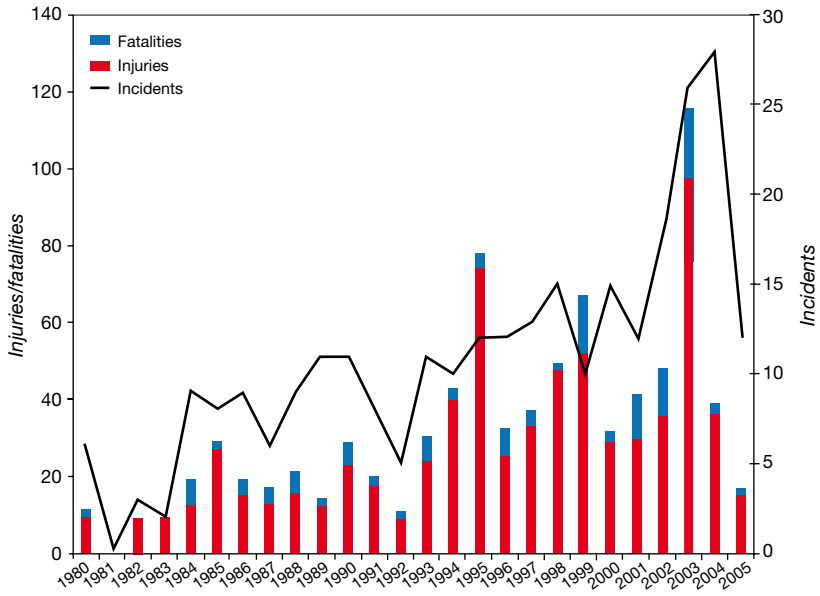


Figure 1: Dust explosion incidents, injuries, and fatalities, 1980–2005 [Source: Report 2006-H-1]

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further reading

1. www.dustexplosions.blogspot.com
2. BIA Report 13/97, *Combustion and explosion properties of dusts*
3. Report 2006-H-1, November 2006, US Chemical Safety and Hazard Investigation Board, *Combustible dust hazard study*
4. Lunn G, *Dust explosion prevention and protection*, Part 1 – Venting, 2nd Edition, IChemE
5. Zeeuwen P, *Dust explosions: What is the risk? What are the statistics?*, Euroforum conference, Paris, March 1997
6. *Equipment use in explosive atmospheres within the pharma, bio and fine chemical industries*, www.icheme.org, Pharma SG page