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The explosion risk in hazardous areas

Hazardous areas are places in industrial facilities where a potentially flammable atmosphere may exist. Such atmospheres usually contain a gas or a vapour but they can also contain dust or fibre.

The ignition triangle



The Ignition Triangle

For there to be fire or explosion in a hazardous area there would need to be:

- A hazard which could be a flammable dust or gas.
- An oxidiser which could be either air or pure oxygen.
- A source of ignition which could either be heat or a spark.

If these three elements are present at the same time and in the right proportions then there will be a fire or an explosion.

The safest way to prevent a fire or explosion is to remove the source of the hazard. However if this cannot be done then the process engineer has to ensure that a source of ignition does not reach the hazard if an oxidiser is present. Alternatively the engineer can ensure that there is no oxidiser present however this is often harder to achieve.

Air is the usual oxidizer as air contains approximately 21% oxygen. If the atmosphere is oxygen enriched i.e. greater than 21% special precautions will need to be taken.



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Examples of sources of ignition include: Motors, switches, solenoids, any hot surfaces, lightning, mobile phones, smoking, welding, static electricity and frictional sparks.

Upper and lower explosive limits

Not all concentrations of flammable gases (vapours) will explode. Explosions can only take place between the upper (UEL) and lower (LEL) explosive limits of a particular gas. (Sometimes also known as the upper and lower flammable limits).

Above the UEL the mixture of substance and air is too rich in fuel (deficient in oxygen) to burn. Below the LEL the mixture of substance and air lacks sufficient fuel (substance) to burn.

For example the LEL of methane (the main component of natural gas) in air is 5%.

Unfortunately, gas/air mixtures are seldom uniform so it is likely that if any amount of combustible gas is detected then at some location the concentration may be explosive.

Minimum ignition energy

The lowest energy that will ignite a mixture of the substance and air at some point between the LEL and UEL is defined as the minimum ignition energy (MIE). Hydrogen has the lowest MIE of all gasses (20 micro Joules).

Auto ignition temperature

The mixture of the substance and air between the LEL and UEL can also be ignited by exposure to a high surface temperature without any source of external ignition (e.g. spark or flame). This is known as the auto ignition temperature (AIT) or spontaneous ignition temperature (SIT). A low MIE does not imply a low AIT. The AIT of hydrogen is quite high at 560 degrees C.

Flash Point

AIT should not be confused with flash point. Flammable liquids normally have a low flash point. This refers to the temperature at which the liquid releases vapours at a rate sufficient to form an explosive mixture with air if a source of ignition is provided. Liquids with flash points below ambient temperature will immediately release dangerous concentrations of gas. Liquid leaks can therefore be as hazardous as gas leaks.

Vapour density

When monitoring for the presence of gases or vapours, it is important to understand vapour density which provides valuable clues as to where a potentially flammable atmosphere may exist.

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This defines if a vapour is heavier or lighter than air. Air has a vapour density (also known as relative vapour density) of 1. Assuming that air currents are negligible, it can be said that gases and vapours with densities less than 1.0, such as methane, will tend to rise from the point of escape and subsequently disperse into the atmosphere or accumulate in spaces under roof structures of buildings. Heavier than air gases such as propane tend to fall from the point of escape, perhaps to floor level where some mixing with air occurs thus creating pockets of mixtures, some explosive, others not. If there are sub-floor spaces such as drain channels, pipe and cable ways and storage pits then these heavier than air gases tend to accumulate there. A suitable source of ignition in such areas will more often than not result in explosion and fire.

Flammable dusts

Many materials produce flammable dust clouds that can explode if ignited. Sugar, carbon, grain, certain metals and approximately 85% of all organic powders behave in this way. Anything that can burn and which exists in a fine powdered form is a risk. Obvious examples of safe powders are sand and cement. Flammability data is much less commonly available for dusts compared to gases and vapours because factors such as particle size can affect the figures so much.

The main risk of ignition of dust hazards is from hot surfaces. Dusts may settle on surfaces and the build up can give rise to a concentration that could be ignited.

Layers of combustible material will burn relatively slowly owing to the limited surface area exposed to the oxygen in the air but if you have the same solid in the form of a fine powder and you suspend it in air as a dust cloud the result will be quite different. In this case the surface area exposed to the air is much larger, and if ignition occurs, the whole of the cloud may burn very rapidly. This results in a rapid release of heat and gaseous products and in the case of a contained dust cloud will cause the pressure to rise to levels which most industrial plant is not designed to withstand.

Although a cloud of flammable dust in air may explode violently, not all mixtures will do so. The concentration of dust and air must be within the upper (UEL) and lower (LEL) explosive limit of the dust in question.

Minimum ignition temperature

Measurements of the LEL of many materials are available. Typically a figure below 40g/m³ is unlikely to support combustion. Upper explosive limits are difficult to measure accurately and are of little practical use. As the risk of ignition is from hot surfaces rather than directly from ignition energy (spark or arc) ignition sensitivity is defined by the minimum ignition temperature (MIT). The gas equivalent of MIT is the AIT. The most violent explosions usually result from dust/air mixtures that are fuel rich.

This means that the oxygen available in the air cannot burn all the dust and glowing, partly burnt, material frequently remains after the explosion. This can reignite if more air becomes available.



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The shape and size of the dust particles, and other factors, strongly affects the force of the explosion and the explosive limits. Explosions are likely to be weak if the mean particle size of the dust exceeds 200 microns or the moisture content is quite high (say above 15%).

Primary and secondary explosions

When a dust cloud ignites in an enclosed volume it results in a very rapid rise in pressure within the container e.g. a silo or closed room. The container may not be strong enough to withstand the pressure from the explosion and it will fail in a sudden and uncontrolled manner. Anyone close to exploding vessel or inside a room where an explosion occurs is likely to be killed or seriously injured. The plant or building will only survive if the design or other protective measures deliberately allows for the high pressures.

Where an item of plant fails, or an explosion vent opens as a result of a dust explosion, a fireball and shockwave will emerge. The fireball is usually much larger than the vessel from which it came, and is likely to spread burning particles a substantial distance. A person engulfed in such a fireball is likely to receive serious burn injuries.

Dust clouds are formed by dust falling into an area or being raised by blasts of air. Dust is heavier than air and therefore it will eventually settle however an explosion within a piece of plant could stir up these dust deposits to create a secondary explosion that is generally more destructive than the primary explosion.

Dust hazards and the ATEX Directive

It is only since July 2003 with the advent of the ATEX Directive that dust atmospheres have been included in those areas where a risk assessment must be carried out. If a hazardous dust zone is identified equipment installed in that zone must conform to the ATEX requirements and any non-conforming equipment must be replaced.

Equipment supplied by K Controls for use in hazardous locations is specially designed, manufactured, tested and certified by a third party agency as suitable for use in such areas. This is to ensure that, even in a fault condition, such equipment could not ignite an explosive mixture of gas or combustible dust.

Further reading

For further reading on the subject Martin Pitt at Sheffield University has compiled some links to some very interesting sites some of which describe in detail major explosions that have taken place at specific locations:

[Collections of Major Incident Reports](#)

[Bhopal 1984](#)

[Flixborough 1974](#)

[Toulouse, 2001](#)

[Other Incidents, Chronologically](#)



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