

## DUST EXPLOSIONS IN MILLS

---

**Published statistics and also our own experiences suggest that particle size reduction equipment such as certain types of mills are perhaps the most likely source of dust explosions experienced in industry when compared to other dust processing/handling equipment.**

---

### WHY DO WE STILL SEE SO MANY DUST EXPLOSIONS IN MILLS?

There are standard fire and explosion tests available to screen out potentially troublesome powders. Furthermore, techniques are well developed to protect plant from the consequences of dust explosions. Is it perhaps that the risks and control measures are not understood sufficiently well by users?

We have put together the following notes to provide some clarification in assessing the potential for dust ignition and explosions during milling operations.

### WHAT TYPE OF MILL CAN CAUSE EXPLOSIONS?

In general, the greater the energy input to a mill, the greater the risk of ignition. Hammer mills and ball mills have produced many explosions over the years, but even air-jet mills are not entirely risk free.

### HOW DOES AN EXPLOSION START?

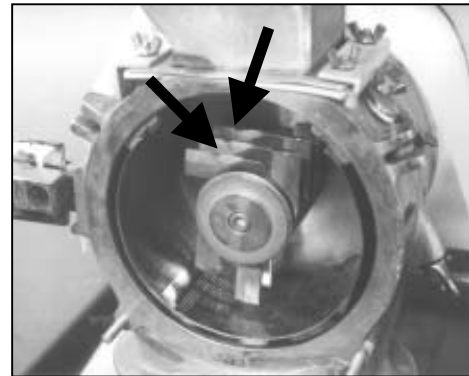
In most milling operations, several different ignition sources can occur. Impact and friction sparks can develop due to the presence of foreign objects or from mis-aligned components. Electrostatic charge generation can lead to incendive discharges and warm/hot spots (from overheated bearings, for example) can start decomposition of self-heating substances.

Ignition sources evolved in these ways can produce dust explosions in connected equipment – such as a receiving drum, dust collector, cyclone or hopper. Thermal decomposition of many materials can also rapidly produce gas in large quantities, and sometimes this gas can be flammable.

### HOW SERIOUS CAN AN EXPLOSION BE?

A common misunderstanding is that because mills are small and generally strong, any explosion can only have minor consequences. This is wrong because the dust volume in connected equipment is many times that of the mill itself. In cases, when gas is generated due to decomposition, the hybrid dust/gas mixture can spread outside the mill. Fire may also follow an explosion with some powders, amplifying their destructive power.

In one case, more than 50% of a factory roof was destroyed due to a decomposition and subsequent explosion in a small batch hammer mill.



*(above) Mechanical damage possibly due to a foreign object entering the mill.*

### ARE YOU AT RISK?

A number of precautions can be taken to prevent and protect against the consequences of a dust explosion in mills of all types. The use of metal separators, temperature probes, and inert gas all have their place, but rarely provide the complete solution. The key to establishing whether your process is at risk is an understanding of the fire, explosion and thermal properties of your powders.

### WHAT IS A TEST PROTOCOL

A test protocol exists for classifying powders as to their suitability for particular mill types – and for identifying the protective measures required if they are to be milled.

The test protocol is designed to:

- Identify potential detonating / deflagrating materials
- Identify those materials which are easily ignited as a dust cloud
- Identify those materials which self heat at low temperatures
- Identify those materials which may generate flammable (or inert) gas when they decompose
- Establish the consequence of the explosion
- Establish suitable prevention and protection methods

The table below summarises the tests for some of the more common “Basis of Safety” for milling operations

Basis of safe operation	Required test(s)	Comments	Discussion
Inert gas blanketing	Limiting Oxygen Concentration (LOC)	Reduces oxygen concentration below minimum necessary to support combustion.	In systems with a large air throughput, nitrogen consumption will be very high unless a recirculation system is used. Plant must be air tight to stop ingress of air and release of nitrogen into the workplace.
Explosion resistant equipment (Containment)	Maximum Explosion Pressure ( $P_{max}$ )	Mill and associated pipework and vessels built strong enough to withstand the maximum explosion pressure.	Containment is relatively easy to achieve for small equipment, but larger equipment, such as associated filters and hoppers may be expensive to build to the required strength. Pressure piling effects are especially severe in fully contained vessels, and isolation measures are of the utmost importance.
Explosion pressure relief venting	Explosion Severity ( $K_{st}$ )	Combustion products are relieved through a vent to limit pressure rise.	Most mills cannot be fitted with vents themselves, but venting is often possible for associated vessels. The need to duct the explosion to a safe area puts constraints on the siting of the equipment and may be incompatible with the sound insulation installed. The use of “flameless venting devices” can overcome these restrictions. If the enclosure housing the mill is vented, access to the enclosure should be restricted.
Explosion suppression	Explosion Severity ( $K_{st}$ )	Initiation of an explosion is detected and a suitable material (suppressant) is injected to extinguish explosion and thus prevent pressure rise.	Explosion suppression can be used on virtually all equipment. On smaller mills it may be difficult to inject the suppressant directly, but the relatively high strength of these units leaves room for alternative solutions. Vibration and mechanical impact can create challenges for the explosion detection system, but solutions are available. A well-designed explosion suppression system will incorporate from the start the necessary isolation measure.
Elimination of potential ignition sources	Minimum Ignition Energy (MIE), Minimum Ignition Temperature (MIT), Bulk Powder Thermal Stability	Using information on the sensitivity of the powder to ignition by sources such as electrostatic discharges, frictional sparks and heating, and thermal decomposition, appropriate steps are taken to exclude ignition sources.	Depending on the test results, steps such as electrical bonding and grounding, regular mechanical maintenance, monitoring of the mill temperature, etc. can reduce the probability of an ignition in the mill. The nature of the operation makes it difficult to use elimination of ignition sources as the “Basis of Safety” for many types of mills. For some mill types, such as air jet mills, it may be feasible depending on the material properties.

#### References:

1. Dust Explosion Prevention and Protection, Part 1 – Venting, Geoff Lunn, 2<sup>nd</sup> Edition, Institution of Chemical Eng., 1992.
2. Dust Explosions in the Process Industries, Rolf K Eckhoff, 2<sup>nd</sup> Edition, Butterworth-Heinemann, 1997.
3. Video Training Package, Dust Explosion Hazards, Package 022, Institution of Chemical Engineers, 1993.

**For additional information regarding our testing protocol for classifying powders as to their suitability for particular mill types – and for identifying the most practical protective measures for safe milling, please contact Mike Weaver. Our Safety Specialists are also available to discuss Chemical Reaction, Dust Explosion, Gas & Vapour Flammability and Electrostatic Hazards.**

**Tel: +44 (0)23 8076 0722 Fax: +44 (0)23 8076 7866 Email: [info@chilworth.co.uk](mailto:info@chilworth.co.uk)**

**Internet: [www.chilworth.co.uk](http://www.chilworth.co.uk)**