DEKRA Dust Explosion Guidance Series

NUMBER 5: POWDER MILLING

Note: ***This guidance note is produced in good faith and may not cover all risks and eventualities with all equipment of this type. If in doubt, our process safety specialist team will be delighted to help you navigate risk assessment, basis of safety definition and testing requirements.***

OVERVIEW

Powder mills are commonly used in industry to reduce the particle size of solid raw materials, intermediates and products. Mill technology ranges from crushers, shredders and granulators, to hammer, ball and pin mills, air classifier or jet mills, colloid and corundum mills. Industry sectors using mills include (but are not limited to) pharmaceutical, chemical, food and drink and consumer goods.

Photograph 1: Corn grinding mill

Photograph 2: Silos in an agricultural setting

SUMMARY OF DUST EXPLOSION RISKS

Most likely intrinsic ignition sources	Most common basis of safety	Test required to support Basis of safety
•Mechanical friction and hot surfaces; •Mechanically generated sparks; •Static electricity; •Unsuitable or malfunctioning equipment.	Avoidance of ignition sources and/or Avoidance of Flammable Atmospheres (inerting) and/or Explosion Protection	•Minimum ignition energy (inductive spark); •Minimum ignition energy (capacitive spark); •Ignition temperature of cloud and layer (MIT and LIT); •Limiting Oxygen Concentration. •Burning Class at 100 °C •Deflagration at 100 °C. •Thermal decomposition testing •Explosion severity testing •Flammable liquids •Impact test

Peripheral / associated risks to consider:

• Mills should also have suitable explosion isolation in place to stop propagation of an explosion up or down stream.

• Where Powder Mills have been installed prior to 2003, they may need to be subject to a Non-Electrical Equipment Ignition Risk Assessment (NEEIRA). However, explosion protection is often needed to achieve acceptable residual risk unless material has low ignition sensitivity (see table).

• Dust filters or other collection systems attached to mills should be subject to a separate ATEX / DSEAR assessment.

• If the material is shock sensitive and can detonate upon impact, then milling should not be carried out. More detailed risk assessments may also be warranted for materials with limited thermal stability.

• Where Explosion Protection is a key part of the Basis of Safety, explosion severity testing will usually be required to verify the adequacy of the protection system fitted.

RISKS

- Compared to other unit operations in the processing industry, milling presents a high ignition likelihood. The high energy input from, e.g. hammer mills, mean that in the event of equipment failure, the resultant impact will produce a high energy ignition source capable of igniting most flammable[1] dusts. Also, due to the nature of this type of mill, a flammable atmosphere is expected usually on a continuous basis.

- Where a risk to people is present in the event of an explosion, inerting or explosion protection (supplemented with explosion isolation) also usually required unless material is very hard to ignite (see table).

- Milled materials are often discharged into open sacks which can result in flammable dust clouds within the workplace. Consideration should always be given to finding a sealed filling solution with overfill protection to reduce the potential for dust entering the workplace and the additional explosion hazard this creates.

[1]Flammable when dispersed as a cloud

POTENTIAL SOURCES OF IGNITION

From the 13 identified sources of ignition taken from EN 1127-1, those which are considered most likely to occur with milling plants are highlighted in the list below:

1. Flames and hot gases (including hot particles)
2. Unsuitable or malfunctioning electrical apparatus
3. Mechanical friction and hot surfaces
4. Mechanically generated sparks
5. Static electricity
6. Chemical reactions and thermal decomposition leading to self-ignition of dusts

With mechanically generated ignition sources being the most likely to occur.

TESTING REQUIRED TO MITIGATE THE POTENTIAL SOURCES OF IGNITION

The powders going through a mill are categorised into "Safety Class for Milling" (SCM) classes and are categorised based on Minimum Ignition Energy (MIE), Minimum Ignition Temperature (MIT), Burning Class, Thermal Stability, the presence of flammable liquids and the result of the Impact test as per the following. All criteria need to be met to support the basis of safety.

- Minimum Ignition Energy (Capacitive assessment) – to assess the potential of incendive spark discharges from isolated conductors and personnel.
- Minimum Ignition Energy (Mechanical spark assessment) – to assess the potential of mechanical sparks.
- Minimum Ignition Temperature (dust cloud) – for correct specification of Temperature Class rating of ATEX equipment and used in conjunction with MIE (mechanical) to assess the potential of mechanical sparks.
- Layer Ignition Temperature (5mm layer) – used with MIT (dust cloud) for the correct specification of Temperature Class rating of ATEX equipment.
- Limiting Oxygen Concentration – the LOC value is used for the determination of the Maximum Permissible Oxygen Concentration (MPOC) within the mixer if an inert atmosphere is present.

Tests required to support Basis of Safety	Avoidance of Ignition Sources	Explosion Protection	Milling is not recommended
• Minimum Ignition Temperature (BAM Method) • Minimum ignition energy (inductive spark)	> 1000 mJ	< 1000 mJ	n/a
• Burning Class at 100 °C	Up to 2	Up to 6	6
Thermal Decomposition Tests: • Self-ignition exothermicity in a fresh air stream (Grewer method) or exothermicity in an open vessel (Lütolf method).	Above 220 °C	90°C - 220 °C	Below 90 °C
Deflagration at 100 °C; this is a special case of thermal decomposition, where decomposition transitions to deflagration.	Negative	Negative	Positive
Flammable Liquids	None	Up to 0.5 wt%	Above 0.5 wt%
Impact test (detonation)	Negative	Negative	Positive

Reference: Milling of combustible solids (1994), ESCIS – Expert Commission for Safety in Swiss Chemical Industry.

Typical Basis of Safety

To reliably apply 'Avoidance of Ignition Sources' as the Basis of Safety, firstly the material must have a low ignition sensitivity as per the table. Then all ignition sources will need to be effectively discounted or mitigated against, as per the testing table.

If ignition sources cannot be reliably controlled due to insufficiently low ignition sensitivity, then vessel inerting or explosion protection should be applied supplemented by explosion isolation measures. Protection could include explosion containment, venting, suppression or a combination of these. Even if protection is fitted (which is far more commonly required than not), ignition sources should still be controlled as much as possible to minimise demand on protection systems.

Other Considerations

Where a proprietary dust filter is used this will require a separate DSEAR risk assessment including Hazardous Area Classification and ignition source review to allow for a robust Basis of Safety to be determined. Mills may have a feed hopper upstream and a buffer hopper or sieve downstream. These will also require a separate DSEAR risk assessment. The potential for propagation of an explosion between interconnected vessels should also be assessed and addressed, where appropriate.

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