Explosion Prevention

Question: *Many food and industrial products produced by member companies are dry powders or crystals. If mishandled, some of these products may form an explosive mixture of air and dust. What are the dust-related hazards and what measures can be taken to prevent dust explosions? A brief overview and information sources follow.*

Summary:

- Combustible dusts are fine particles that present an explosion hazard when suspended in air under certain conditions. A dust explosion can cause catastrophic loss of life, injuries, and destruction of buildings.

- OSHA created the Hazard Communication Standard (HCS) to ensure that the hazards of all chemicals produced or imported are evaluated and that information concerning their hazards is transmitted to employers and workers.

- Historical testing shows that most of the food and industrial products produced by member companies have K_{St} values < 200 bar-m/s, placing them in the St-1 Dust Class.

Combustible Dust Definition
According to OSHA[1], any combustible material (and some materials normally considered non-combustible) can burn rapidly when in a finely divided form. If such a dust is suspended in air in the right concentration, it can become explosive. The force from such an explosion can cause employee deaths, injuries, and destruction of entire buildings.

Materials that may form combustible dust include metals (such as aluminum and magnesium), wood, coal, plastics, cornstarch, biosolids, sugar, paper, soap, dried blood, and certain textiles.

OSHA lists five factors that must be present to cause an explosion:

1. Oxygen
2. Heat
3. Fuel
4. Dispersion
5. Confinement

If one of the above five elements is missing, an explosion cannot occur.

Government Standards and Regulation

Under the Occupational Safety and Health Act of 1970, employers are responsible for providing a safe and healthy workplace for their employees. Section 5(a)(1) of the OSH Act, often referred to as the General Duty Clause, requires employers to "furnish to each of his employees employment and a place of employment which are free from recognized hazards that are causing or are likely to cause death or serious physical harm to his employees".Section 5(a)(2) requires employers to "comply with occupational safety and health standards promulgated under this Act".

The HCS comprehensively addresses the evaluation of the potential hazards of chemicals and the communication of hazard information to workers (29 CFR 1910. 1200(a)(2)). It is a performance-oriented standard that applies to any chemical known to be present in the workplace in such a manner that workers may be exposed under normal conditions of use or in a foreseeable emergency (29 CFR 1910.1200 (b)(2)). Regarding dusts and other particulates, a hazard evaluation must be conducted taking into consideration all discernible hazards, including that of explosibility. It is incumbent upon manufacturers and importers to provide information on the potential for and control of combustible dusts. [See *CPL 02-02-038 Inspection Procedures for the Hazard Communication Standard* (updated in 1998); *CPL 03-00-008 Combustible Dust National Emphasis Program* and letters of interpretation (Mattingly, 1986; English,1987)].

Hazard Assessment

OSHA recommends a thorough hazard assessment of the following:

1. All materials being handled
2. All operations conducted – including by-products
3. All spaces (including hidden ones)
4. All potential ignition sources

Identifying and Controlling the Potential for Dust Explosions

The hazard determination must include an assessment of all physical and health hazards. The chemical manufacturer or importer must consider the potential exposures that may occur under normal conditions of use or in foreseeable emergencies, and address known hazards on the MSDS and, where appropriate, on the label prepared for the product.
(http://www.osha.gov/Publications/3371combustible-dust.html)

- **MSDS Preparation**

The HCS requires chemical manufacturers and importers to develop an MSDS for each hazardous chemical they produce or import.
Examples of combustible dust warning information on the MSDS can be found in the ANSI (Z400.1).

- **Product Labels**

Containers of material with HCS physical and health hazards are subject to the labeling requirements of the HCS (29 CFR 1910.1200(f)). Manufacturers, importers and distributors are required to assess available evidence regarding a product's hazards and must consider exposures under normal conditions of use or in foreseeable emergencies when evaluating what hazards must appear on the label. Where manufacturers are aware that the downstream use of their product routinely generates combustible dusts, a warning addressing a potential explosion hazard should be included on the label as an immediate visual reminder.

An example of combustible dust warning information on a label:

Warning: May Form Combustible (Explosive) Dust - Air Mixtures
Keep away from all ignition sources including heat, sparks and flame. Keep container closed and avoid creating airborne dust. Prevent dust accumulations to minimize explosion hazard.

Explosivity and K_{st} Values

As reported in OSHA's *Hazard Communication Guidance for Combustible Dust*[3], an initial (primary) dust explosion in processing equipment may shake loose accumulated dust, or damage a containment system (such as a duct, vessel, or collector). This causes the dust to become airborne and this additional airborne dust, if ignited, may cause one or more secondary explosions. These can be more destructive than a primary explosion due to the increased quantity and concentration of dispersed combustible dust and the larger ignition source potentially provided by the initial explosion.

The ease of ignition and the severity of a combustible dust explosion are typically influenced by particle size. Other factors that influence the explosiveness of dusts include moisture content, ambient humidity, oxygen available for combustion, the shape of dust particles, and the concentration of dust in the air.

Physical properties used to measure combustible dusts include:

- MIE, the minimum ignition energy, which predicts the ease and likelihood of ignition of a dispersed dust cloud.
- MEC, the minimum explosible concentration, which measures the minimum amount of dust dispersed in air required to spread an explosion. (The MEC is analogous to the Lower Flammable Limit (LFL) or Lower Explosive Limit (LEL) for gases and vapors in air).
- K_{st}, the dust deflagration index, measures the relative explosion severity compared to other dusts. The larger the value for K_{st}, the more severe the explosion (See Table, below). K_{st} provides the best "single number" estimate of the anticipated behavior of a dust deflagration.

Table 1: Examples of K_{st} Values for Different Types of Dusts[4]

Dust explosion class*	K_{st} (bar.m/s)*	Characteristic*	Typical material**
St 0	0	No explosion	Silica
St 1	>0 and ≤200	Weak explosion	Powdered milk, cornstarch, charcoal, sulfur, sugar and zinc
St 2	>200 and ≤300	Strong explosion	Cellulose, wood flour, and poly methyl acrylate
St 3	>300	Very strong explosion	Anthraquinone, aluminum, and magnesium

The actual class is sample specific and will depend on varying characteristics of the material such as particle size or moisture.
*OSHA CPL 03-00-008 - Combustible Dust National Emphasis Program. Note that a stronger explosive force than nominally indicated could potentially occur if other conditions were to be present (e.g., unusually large ignition source, other flammables present).
** NFPA 68, Standard on Explosion Prevention by Deflagration Venting.

Specific guidance measures to prevent explosions can be found in OSHA's SHIB *Combustible Dust in Industry: Preventing and Mitigating the Effects of Fire and Explosions*, which lists measures to control dusts, eliminate ignition sources, and limit the effects of explosions to minimize injuries.

Refer to NFPA 654, *Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids*, for safe handling. The standard applies building construction requirements and equipment isolation methods to mitigate the consequences of fires and explosions. The standard also addresses selection and design of protective systems by referencing other NFPA standards (such as NFPA 68 and 69).

NFPA 68, *Standard on Explosion Prevention by Deflagration Venting*, applies to the design, location, installation, maintenance, and use of devices and systems that vent the combustion gases and pressures resulting from a deflagration within an enclosure so that structural and mechanical damage is minimized.

References

1. OSHA Fact Sheet: Hazard Alert: Combustible Dust Explosions, www.osha.gov.

2. OSHA Combustible Dust Safety and Health Topics Page, (www.osha.gov/dsg/combustibledust/index.html)

3. Hazard Communication Guidance for Combustible Dust, www.osha.gov.

4. Hazard Communication Guidance for Combustible Dust, www.osha.gov.

5. FPRF Combustible Dust Symposium, *NFPA Combustible Dust Hazard Codes and Standards*, www.nfpa.org.

6. National Fire Protection Association, *Codes and Standards*, www.nfpa.org.