WHITE PAPER

Controlling Dangerous Grain and Seed Dusts

Many grain mill, silo and seed processing plant operators don't realize the dangers of airborne grain particles. Applications like corn shelling, seed cleaning, seed preparation and seed coating produce dust that poses both occupational exposure and combustible dust risks. This white paper examines these dangers, applicable regulatory guidelines and how high-efficiency dust collection systems help keep workers safe and facilities in compliance.

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Dust Hazards in Agricultural Seed Processing

Dust is produced when moving, storing and processing seeds and grains. These dust particles often become airborne, which can threaten employee health and cause combustible dust incidents. Dust particles vary in size, and some are so fine they are not visible to the naked eye.

Facilities must comply with Occupational Safety & Health Administration (OSHA) regulations to protect their employees from exposure to airborne dusts, as well as National Fire Protection Association (NFPA) standards to provide a safe working environment.

In addition, agricultural facilities and processors must follow regulations from the United States Department of Agriculture (USDA) and Food and Drug Administration (FDA), which recently began implementing the Food Safety Modernization Act (FSMA).

It's essential for facilities to control food dusts that are generated because these dusts can:

- Harm human health and negatively impact the environment.
- Cross-contaminate and proliferate the spread of pathogens and allergens.
- Become combustible and cause explosions that harm workers, damage machinery, and destroy buildings and corporate reputations.

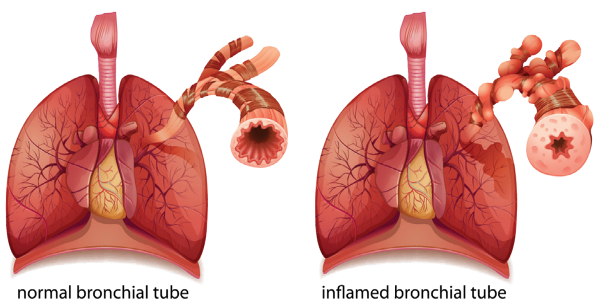
Processes that create seed dust hazards include:

- silos/grain storage
- corn shelling
- seed cleaning
- seed preparation
- seed coating
- seed hybrid development

Occupational Exposure

Regular exposure to certain types of fine dust particles can produce minor allergic reactions on the skin such as dermatitis. Such conditions are uncomfortable for workers and require treatment and protective work wear, which can affect an employee's performance and well-being. However, the respiratory distress that dust allergens can cause is far more serious. The finest dust particles readily become airborne and are easily inhaled, penetrating deep into the lungs. They can cause life-threatening conditions such as occupational asthma as well as chronic, long-term health issues including lung cancer.

Asthma-Inflamed Bronchial Tube



Inhaled dust particles can cause life-threatening conditions.

OSHA regulations govern employers whose processes generate dust, and they will issue citations and fines for lack of compliance. Employers are required to protect workers from exposure, and each facility will have its own unique set of process conditions. Under OSHA, facilities must control dust emissions into the indoor workplace atmosphere to comply with legal limits set for a particular material. If no legal limits are applicable, then the company is required to define in writing, implement and measure its own environmental safety plan.

Cross-Contamination

Dust from airborne particles can lead to cross-contamination.

Cross-contamination is another serious issue. Food contamination and foodborne illness cause recalls that cost food manufacturers hundreds of millions of dollars. Traveling dust in a processing facility can cause a pathogen outbreak from the spread of microorganisms or allergen exposure.

Preventing cross-contamination requires effectively collecting and removing all contaminants before they become widely dispersed. Collecting, controlling and filtering pathogens and allergens minimize the spread of harmful contaminants and keeps them from returning to the processing environment.

High-efficiency dust collectors help seed and feed processors meet specific food safety hazard and quality controls, limit cross-contamination in production lines, and prevent the spread of allergens. They also increase compliance with the FDA's Good Manufacturing Practices (GMPs) and Hazard Analysis and Critical Control Points (HACCPs).

Combustible Dust Explosions

A dust explosion occurs when a confined and concentrated combustible dust cloud comes into contact with an ignition source. Many seed and grain processes produce explosive dusts. Good housekeeping and installing a well-designed dust collection system can prevent airborne dust from building up in the work environment, on electrical equipment and on other areas where dust can accumulate, such as false ceilings.

These measures help to negate the risk of a primary or secondary explosion. The primary explosion is the first point where an explosion occurs and is usually an isolated incident. A secondary explosion occurs when the primary explosion pressure disturbs the dust collected in the areas mentioned above, creating a far more extensive and potentially deadly explosion.

Regulations Governing Occupational Exposure and Cross-Contamination

OSHA

OSHA 1910 is a broad, general standard that covers most industries. It is a comprehensive and complex standard with 20 subsections. The only food industry sector that has its own separate standard is agriculture, which is covered by OSHA 1928.

Here are key parts of OSHA 1910 that are important to the seed processing industry and require dust control:

1910.22: Walking-Working Surfaces. This housekeeping standard requires that all places of employment, passageways, storerooms, service rooms and walking-working surfaces are clean, orderly, dry, sanitary and free from hazards. This means that facilities must prevent dust from accumulating on these surfaces.

1910.134: Personal Protective Equipment (PPE). These requirements aim to minimize occupational diseases caused by breathing air contaminated with harmful dusts, fumes, mists, gases, smokes, sprays or vapors. It recommends accepted engineering control measures to mitigate these risks.

Seed processing facilities are vulnerable to combustible dust.

1910.272: Grain Handling Facilities. This section contains requirements for the control of grain dust fires and explosions, and certain other safety hazards associated with grain handling facilities. Because fugitive grain dust is so highly combustible, OSHA requires employers to develop and implement a written housekeeping program. They must establish the frequency and methods determined best to reduce accumulations of fugitive grain dust on ledges, floors, equipment and other exposed surfaces.

Grain handling facilities must follow OSHA 1910.272.

This section also notes that all fabric dust filter collectors that are a part of a pneumatic dust collection system must be equipped dust collector filters. The standard also includes rules for filter placement.

1910:307: Hazardous (Classified) Locations. This section covers the requirements for electric equipment and wiring in locations where there is a risk of fire or explosion because of the presence of flammable vapors, liquids or gases, or combustible dusts or fibers. The National Electrical Code (NEC) defines hazardous location types. Most food processing facilities are Class II, Division 1 locations, where there is a sufficient amount of combustible dust present in the air to be explosive or ignitable under normal, everyday operating conditions.

FDA

The FDA's Food Safety Modernization Act (FSMA) requires facilities that proces food ingredients to implement measures to minimize or prevent contamination hazards. These include controls for processes, food allergens, sanitation and supply chain, as well as having a recall plan. Food processors must also include and document actions to:

- Identify and correct a problem, implementing a preventive control.
- Reduce the likelihood the problem will recur.
- Evaluate affected foods for safety.
- Prevent those food products from entering commerce if they cannot ensure that the affected food is not adulterated.

FSMA gives the FDA the authority to suspend a food facility's registration if there is a "reasonable probability" the food product in question will cause serious adverse health consequences or death to humans or animals. A suspended license means the food produced in that facility can no longer be sold.

Even if a facility's circumstance doesn't reach the point of suspension, FSMA non-compliance can be expensive. The new law is funded in part by non-compliance fees based on two types of tasks: those related to reinspecting facilities found to be non-compliant and those related to non-compliance with a recall order.

The fee schedule for FY2018 is effective from October 1, 2017, through September 30, 2018. The current hourly fees are: $248 if domestic travel is required, $285 if foreign travel is required. This means that if a food processor doesn't comply with FSMA, and the FDA has to reinspect that facility, the company will receive a bill from the government. Billable time consists of hours spent on reinspections including all activities outside of the actual inspection, like travel and preparing the report. For non-compliance with recalls, billable time again consists of all direct hours. This includes time spent conducting and analyzing audit checks, reviewing reports and traveling.

Food Safety Modernization Act requires facilities that process food ingredients to implement measures to minimize or prevent contamination hazards.

USDA

The mission of the USDA Food Safety and Inspection Service (FSIS) is to protect the public's health by ensuring the safety of meat, poultry and processed egg products. As a public health regulatory agency, FSIS investigates reports of foodborne illness associated with FSIS-regulated products. If these foodborne illness investigations determine that a food product contains a pathogen or is otherwise harmful to human health, FSIS could recommend a recall of that item. A recall committee is then convened to discuss the investigative findings and to determine whether the agency should recommend a recall to prevent further human exposure to the product. Other possible agency actions—like initiating criminal, civil or administrative action—depend on the evidence collected and how strongly human illness is linked to the FSIS-regulated product.

CONTROLLING EXPOSURE TO DUST

The best way to reduce workers' exposure to and cross-contamination from hazardous dusts is to install dust collection systems with high-efficiency primary and secondary cartridge-style filters. Primary filter media should be selected for each application based on the dust particle size, flow characteristics, quantity and distribution. If the primary filtration system does not use a HEPA filter, it is recommended that a secondary HEPA filter be used downstream. Secondary filters prevent hazardous dusts from discharging into the atmosphere and can be configured to prevent return air ducting contamination and the associated costs of cleaning hazardous dust leakage.

A wide, uniformly pleated filter allows the collected dust to release from the filter, keeping the resistance lower through the filter for a longer time. When the pleats of the filter media are tightly packed, the reverse pulse cleaning system of the dust collector will not eject the dust that has settled in between the pleats. Tightly packed pleats increase the resistance of the air through the filters and diminish airflow.

There are two basic categories of media commonly used in pleated cartridge filters. The choice is usually driven by dust type, operating temperatures and the level of moisture in the process:

- Nonwoven cellulosic blend media is the most economical choice for dry dust collection applications at operating temperatures up to 160 °F (71 °C).
- Synthetic polyester media or polyester-silicone blend is a lightweight, washable media that can handle dry applications with maximum operating temperatures ranging from 180 °F (82 °C) to 265 °F (129 °C). These filters are washable and can recover from a moisture excursion, but they are not intended for wet applications.

Standard and nanotechnology filter media treated with a flame retardant are recommended for applications considered a fire risk. Conductive or antistatic filters may be used where conveyed dusts generate static charges that require dissipation. Cartridge filters with antistatic media can also be used in explosive dust applications, making it possible to conform to NFPA requirements and lessen the risk of ignition sources due to static electricity charges.

High-efficiency dust collection systems also use self-cleaning mechanisms that regularly pulse dust off the filters, allowing units to run longer between filter change-outs. When a layer of nanofibers is applied on top of the base filter media, it promotes surface loading of fine dust and prevents the dust from penetrating deeply into the filter's base media. This translates into better dust release during cleaning cycles and lower pressure drop readings through the life of the filter.

Multiple dust collectors in use at a grain processing operation.

REGULATIONS GOVERNING COMBUSTIBLE DUST

In the United States, there are three key entities involved in combustible dust issues, each with its own particular area of responsibility:

NFPA sets safety standards regarding combustible dust, amending and updating them on a regular basis. Together, NPFA's standards add up to total protection to prevent an explosion, vent it safely, and/or ensure that it will not travel back inside a building. Most insurance agencies and local fire codes state that NFPA standards shall be followed as code. Exceptions would be where the authority having jurisdiction (AHJ), such as Factory Mutual or local fire marshals, specifies an alternative safety approach, which might be even more stringent.

OSHA, together with local authorities, enforces the standards published by NFPA. OSHA's Combustible Dust National Emphasis Program (NEP) outlines policies and procedures for inspecting workplaces that create or handle combustible dusts. The Combustible Dust National Emphasis Program applies to 64 industries (SICs/NAICs), including wood products, food products, metal products, chemicals, pharmaceuticals, rubber and plastic products, paper products, furniture, electric and sanitary services, transportation equipment, durable goods and textile mills.

RELEVANT NFPA STANDARDS

Wide-pleated dust filter media.

In trying to sort through the list of combustible dust standards, a good starting point for every feed or grain processing facility manager is NFPA 652, the Standard on the Fundamentals of Combustible Dust. This covers the requirements for managing combustible dust fires and explosions across industries, processes and dust types. This standard applies to all facilities that produce or handle combustible dust, not just hazardous or classified locations. The owner or operator of any facility where combustible dust exists is responsible for conducting a dust hazard analysis (DHA) to identify the hazards, creating a plan for managing the hazards and providing training for anyone affected by the hazards.

NFPA 654, the Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing and Handling of Combustible Particulate Solids, is an all-encompassing standard on how to design a safe dust collection system. It is the most general on the topic, and it will lead you to other relevant documents. Depending on the nature and severity of the hazard, NFPA 654 will guide you to the appropriate standard(s) for explosion venting and/or explosion prevention, as follows:

NFPA 61 – Standard for the Prevention of Fires and Dust Explosions in Agricultural and Food Processing Facilities. This standard covers facilities:

- Engaged in dry agricultural bulk materials including grains, oilseeds, agricultural seeds, legumes, sugars, flours, spices, feeds, and other related materials;
- Manufacturing and handling starch;
- Using seed preparation and meal-handling systems of oilseed processing plants not covered by NFPA 36, Standard for Solvent Extraction Plants.

Examples of facilities covered by NFPA 61 include, but are not limited to, bakeries, grain elevators, feed mills, flour mills, corn and rice milling, dry milk products, mix plants, soybean and other oilseed preparation operations, cereal processing, snack food processing, tortilla plants, and chocolate processing.

NFPA 68 – Standard on Explosion Protection by Deflagration Venting. This document focuses on explosion venting on devices and systems that vent combustion gases and pressures resulting from a deflagration within an enclosure, for the purpose of minimizing structural and mechanical damage. The current edition, published in 2018, contains much more stringent requirements than past editions, essentially elevating it from a guideline to a standard.

NFPA 69 – Standard on Explosion Prevention Systems. This standard This Standard applies to the design, installation, operation, maintenance, and testing of systems for the prevention of explosions by means of the following methods:

(1) Control of oxidant concentrations

(2) Control of combustible concentration

(3) Predeflagration detection and control of ignition sources

(4) Explosion suppression

(5) Pasive isolation

(7) Deflagration pressure containment

(8) Passive explosion suppression

NFPA 70 – National Electrical Code (NEC). The NEC covers everything related to the installation of electrical equipment across all industries and all types of buildings. This code is enforced in all 50 states. Food manufacturers need to be aware of two main sections of NFPA 70 because they apply to housekeeping: combustible dust definition and hazardous locations. NFPA 70 defines combustible dust as “dust particles that are 500 microns or smaller and present a fire or explosion hazard when dispersed and ignited in air.” The NEC defines different classes of hazardous (classified) and non-hazardous locations. These classes determine the wiring of buildings and also the equipment and housekeeping procedures that can be used in different areas of facilities.

Dust collector at a corn shelling operation.

Mitigating Combustible Dust

DUST ANALYSIS

It is critical to know the explosive potential of the dusts, gases and dust/gas mixtures emitted when processing grains and seeds. NFPA states that a hazard analysis is needed to assess risk and determine the required level of fire and explosion protection from combustible dust. The analysis can be conducted internally or by an independent consultant, but either way the authority having jurisdiction will ultimately review and approve the findings.

The first step in a hazard analysis is determining whether your dust is explosive. NFPA classifies dusts according to their explosibility, that is, their Kst values. Kst is the normalized maximum rate of explosion pressure rise, measured in bar m/s. A bar is a metric unit of pressure, which is slightly less than the average atmospheric pressure on Earth at sea level.

NFPA Class ST1 dusts are rated below 200 Kst, Class ST2 dusts range from 200 to 300 Kst, and Class ST3 dusts are rated above 300 Kst. As a rule of thumb, when dusts approach 600 Kst, they are so explosive that wet collection methods are recommended. However, any dust above 0 Kst is considered to be explosive, and the majority of dusts fall into this category. If OSHA determines that even a very low Kst dust is present in a facility with no explosion protection in place, a citation will result, per OSHA’s NEP policy.

In addition to Kst, it is important to know other combustible dust properties such as Pmax (the maximum explosion pressure of a dust cloud, measured in bar) and Pred (the maximum pressure developed in a vented enclosure during a vented deflagration). These can be determined using ASTM E1226-10, Standard Test Method for Explosibility of Dust Clouds.

Your dust collection equipment supplier will need the Kst and Pmax values in order to correctly size explosion venting or suppression systems. In addition to conducting explosibility testing to determine whether a dust is combustible, it is important to analyze other dust characteristics to determine the best dust collection system and filters for your food processing operation. Other key dust properties to know include particle size, dust shape, gravity, moisture level and abrasiveness. Understanding these components leads to the optimal design of dust-control equipment.

The first step in a hazard analysis is determining whether your dust is explosive.

DUST COLLECTORS AND EXPLOSION PROTECTION

Combustible dust explosions are a risk in many areas of grain and seed processing facilities, but one of the most common locations is the dust collection system itself. There are many types of devices and systems used to protect dust collectors so that they comply with NFPA standards. They fall into two general categories: passive and active.

Passive devices include:

Explosion venting: Designed to be the "weak link" of the dust collector vessel, an explosion vent opens when predetermined pressures are reached inside the collector, allowing the excess pressure and flame front to exit to a safe area. It is designed to minimize damage to the collector and prevent it from blowing up in the event of a deflagration, thereby reducing the safety hazard.

Understanding the pressure capabilities of your collector is important in the specification and calculations of vent sizing. Comparing venting vessel strength to the deflagration strength and vent burst pressure is key to effective deflagration protection.

Burst pressure of the vent is designed to be lower than enclosure strength, which will relieve the pressure of the deflagration before it can build to levels that would destroy the collector enclosure.

Flameless venting: Designed to install over a standard explosion vent, a flameless vent extinguishes the flame front exiting the vented area, not allowing it to exit the device. This allows conventional venting to be accomplished indoors where it could otherwise endanger personnel and/or ignite secondary explosions. A safe area around the flameless vent still needs to be established due to the release of pressure and dust/gases.

Passive float valve: Designed to be installed in the outlet ducting of a dust collection system, this valve utilizes a mechanical barrier to isolate pressure and flame fronts caused by the explosion from propagating further through the ducting. The mechanical barrier reacts within milliseconds and is closed by the pressure of the explosion.

Backdraft damper: A mechanical backdraft damper is positioned in the inlet ducting. It utilizes a mechanical barrier that is held open by the process air and is slammed shut by the pressure forces of the explosion. When closed, this barrier isolates pressure and flame fronts from being able to propagate further up the process stream.

Combustible Dust Properties

- **Kst** – Deflagration index (bar m/s)
- **Pred** – Reduced pressure after venting (bar)
- **Pstat** – Vent static burst pressure (psi)
- **Pmax** – Max pressure for an unvented dust explosion (bar)
- **(dp/dt)** Rate of pressure rise (bar/s or psi/s)
- **Pes** – Enclosure strength = 2/3 of yield strength of weakest part or 2/3 of ultimate strength if deformation is allowed

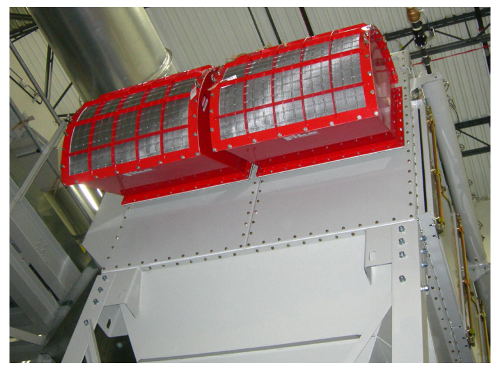
Flame front diverter: This device diverts the flame front to the atmosphere and away from the downstream piping. Typically, this device is used between two different vessels equipped with their own explosion protection systems. The flame front diverter is used to eliminate "flame jet ignition" between the two vessels that could overpower the protection systems installed.

Active devices include:

Chemical isolation: Designed to react within milliseconds of detecting an explosion, a chemical isolation system can be installed in inlet and/or outlet ducting. Typical components include the isolation canister, explosion pressure detector(s) and a control panel. This system creates a chemical barrier that suppresses the explosion within the ducting, eliminates the propagation of flame through the ducting, and minimizes pressure increase within connected process equipment.

Chemical suppression: Whereas chemical isolation is used to detect and suppress explosions within the ducting, chemical suppression protects the dust collector itself. It is often used, together with isolation, when it is not possible to safely vent an explosion or when the dust is harmful or toxic. The system detects an explosion hazard within milliseconds and releases a chemical agent to extinguish the flame before an explosion can occur.

Fast-acting valve: Designed to close within milliseconds of detecting an explosion, the valve installs in inlet and/or outlet ducting. It creates a mechanical barrier within the ducting that effectively isolates pressure and flame fronts from either direction, preventing them from propagating further through the process.

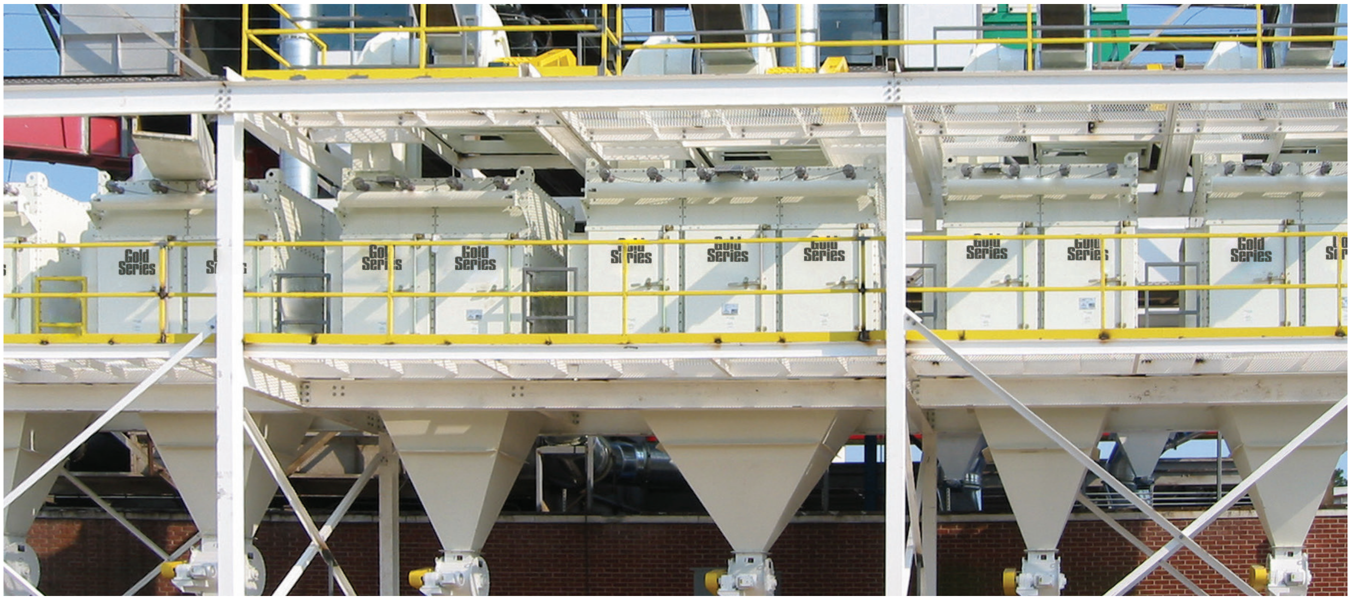


For dust collectors installed indoors, flameless venting provides a safe option to mitigate combustible dust explosions.

Summary

Seed and grain storage and processing facilities are morally and legaly bound to control the dangersous dusts they produce. These dusts can cause serious harm to employee health, reduce product quality, and cause devastating explosions that can hurt or kill workers and bring irreparable damage.

A high-efficiency dust collector designed specifically for your operation is an accepted and proven engineering control that will filter hazardous contaminants to make indoor environments safer. With the help of engineering consultants and reputable, experienced equipment suppliers, seed and grain processing facilities can minimize risk factors and maximize combustible dust safety.



Multiple dust collectors on corn processing application.

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