

Aluminum Dust Management in a Metallizing Facility Safety and Regulatory Concerns

William James Barlow, Jr., Product Development Engineer, National Accounts Division
Printpack, Inc., Villa Rica, GA

Abstract:

According to the Occupational Safety and Health Administration (OSHA), a combustible dust is a particulate solid of organic, unoxidized metal particles, or other oxidizable material that presents a fire or deflagration hazard when suspended in air or some other oxidizing medium over a range of concentrations regardless of size or shape. Due to the deadly history regarding related combustible dust explosions within multiple industrial operations, federal regulations are now being enforced at a much higher level to ensure the protection of every employer and employee within the workplace. There are plenty of safety regulations and guidelines available from OSHA, NFPA, etc. to ensure proper implementation and continual best practices, especially in the area of industrial dust control. This following document summarizes the latest information available regarding the regulations and guidelines currently being enforced by OSHA, NFPA, etc. specifically in the area of aluminum/metal dust, with a focus on the metallizing industry. Briefings will include details on the following subjects: industry codes, standards, classifications, types of hazards, monitoring, measurements and assessments, approved procedures and devices for implementing and maintaining good house keeping practices, approved equipment and electrical operation, proper ventilation and exhaust systems, and storage, within an aluminum dust generating environment.

Introduction:

Whether you are aware of the facts or not, accumulated fine particulates, dust, derived from any combustible material and from some materials generally not considered combustible, can rapidly ignite and burn,

causing injury and even death among our fellow colleagues in industry. As accumulated dust is disrupted, which frequently occurs in a normal routine work environment, it becomes suspended in air, and if in just the right concentration in air, it is considered and has proven to be an explosive material. These dusts include: aluminum, magnesium, wood, coal (carbon dusts), plastics and additives, bio-solids, certain textiles, and even organics such as sugar, flour, paper, soap, and dried blood. There is no doubt that good housekeeping practices need to be implemented by employers to reduce physical injury and minimize employee exposure to health hazards.

The goal of this paper is to provide facts and resources so that the proper decisions are being made that involve the valuable workforce and resources that make the business what it is today. Ultimately, it is the employers' responsibility to determine their own risk regarding their environment and to ensure the proper regulations and guidelines are followed that accompany the employers' assessment(s). If unapproved items or devices are used within the hazardous dust environment, companies are at risk of violating current established provisions.

Background:

According to the U.S. Chemical Safety and Hazard Investigation Board (CSB), there have been 281 combustible dust incidents between 1980 and 2005 that have killed 119 and injured 718 workers, extensively damaging the industrial facilities that contained the explosions. These combustible dust incidents have occurred in forty-four states, covering a variety of industries, involving many different materials. Figure 1 below is a pie chart outlining data from the CSB showing the wide range of materials

causing combustible dust incidents; wood, food-related products and metals each accounting for over 20 percent of explosions, with plastics accounting for 14 percent.

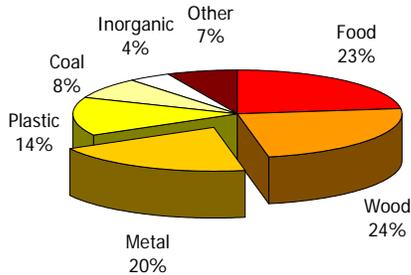


Figure 1: Pie chart showing the wide range of materials causing combustible dust incidents. Data taken from CSB findings.

Exponent® Engineering and Scientific Consulting explains the two types of explosions, deflagration and detonation, quite nicely. In a deflagration, combustion or reaction waves propagate at velocities less than the speed of sound. Exponent® states that all combustion can be defined as a deflagration, where the ignition of a fuel-oxidizer mixture, or in our case, a suspended cloud of combustible dust in a confined environment, such as a building, causes rapid increases in pressure, causing explosions with extensive damage. Additionally, Exponent® states that these explosions are typically associated with gas, vapors, or finely divided fuels, dust, and certain reactive chemicals. In a detonation, combustion or reaction waves propagate at velocities faster than the speed of sound. Due to the extremely fast reactions associated with detonation, these explosions create high-pressure shock waves that can cause damage at distances far from the origin of the blast.

The familiar “fire triangle”, seen in Figure 2, shows that for a fire to occur, three components, fuel, ignition and oxygen must be present simultaneously. The fuel can be a gas, a vapor or a combustible dust (e.g. aluminum from metallizing process). The

oxidant is typically oxygen in the surrounding ambient air; however other oxidants such as chlorine or nitric oxide are effective in supporting combustion as well. Ignition sources encompass heat sources such as sparks, naked flames, or elevated temperatures. The fuel and the oxidant are separate in a fire and need to be present at just the right concentrations; the ignition source must have enough energy to ignite the fuel-oxidant mixture. Like all fires, a dust fire occurs when fuel, the combustible dust, is exposed to heat, or ignition source in the presence of oxygen. Removing any one of these elements of the classic fire triangle eliminates the possibility of a fire.

Combustible dusts are typically explosible if the dust has a particle size less than 420 microns (passing thru a U.S. No. 40 standard sieve), or a particle with a surface area to volume ratio greater than a 420 micron diameter sphere. Some flaky and fibrous materials may also be a hazard even though they will not pass thru a #40 sieve. Even with this stated, a dust explosion still requires the simultaneous presence of two additional elements—dust suspension and confinement, seen in Figure 3 below. Suspended dust burns more rapidly, and confinement allows for pressure buildup. Removal of either the suspension or the confinement elements prevents an explosion, although a fire may still occur.

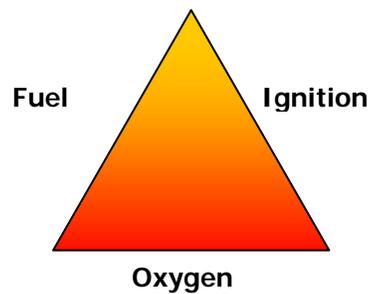


Figure 2: Typical “fire triangle”.

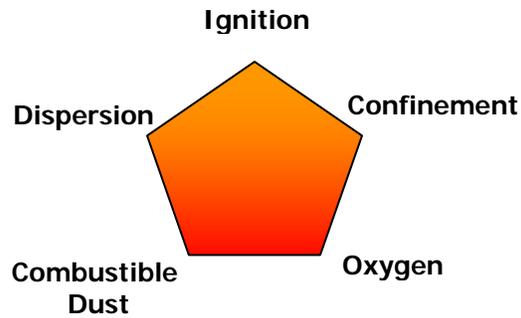


Figure 3: Combustible dust pentagram.

A Combustible Dust Incident:

As reported by the Chemical Safety and Hazard Investigation Board (CSB), on October 29, 2003, aluminum dust exploded at the Hayes Lemmerz International facility in Huntington, Indiana, subsequently killing one worker and injuring several others. The Hayes Lemmerz plant manufactures cast aluminum automotive wheels. The explosions were fueled by the accumulation of aluminum dust, a byproduct of the wheel production process. Below in Figure 4 is a picture of the Hayes Lemmerz International facility after the explosion from aggravated aluminum metal dust accumulation.



Figure 4: A picture of the Hayes Lemmerz International facility after the explosion from aggravated aluminum metal dust accumulation.

As scrap aluminum from the wheel manufacturing process was chopped into small chips, it was pneumatically conveyed to a scrap processing area where it was

dried and then fed into a melt furnace. The process of transporting and drying the aluminum scraps subsequently generated aluminum dust in the ambient atmosphere, which was then pulled into a dust collector. It was reported that the dust collection system installed was not specifically designed to handle or maintain the dust, preventing an explosion, or preventing a subsequent explosion from spreading through ducting. As all 5 requirements for combustion were present, an explosion occurred.

Classifications and Standards:

According to the Occupational Safety and Health Administration (OSHA), the presence of combustible materials in sufficient amounts or concentrations in any location, or in a location where sufficient concentrations could exist to produce an ignitable mixture, it is considered a hazardous location. The location becomes classified as a Class II hazardous location when the combustible material is a combustible dust. The fact is that the metallizing process does produce aluminum dust as a byproduct and aluminum dust can be considered a combustible dust.

A Class II, Division 1 hazardous location, according to the National Fire Protection Association (NFPA) guidelines, is identified as any location in which (1) combustible dust is in the air under normal operating condition is present in sufficient quantities to produce explosive or ignitable mixtures, (2) combustible dust accumulates on horizontal surfaces greater than 1/8", making the surface color undeterminable, (3) mechanical failure or abnormal operation of equipment might cause such explosive or ignitable mixtures to be produced, providing a source of ignition through simultaneous failure of electric equipment, (4) combustible dusts of an electrically conductive nature may be present in hazardous or sufficient quantities. NFPA guidelines identify a Class II, Division 2 area as a location where dust has accumulated on horizontal surfaces less than 1/8" and the surface color is undeterminable.

Combustible dusts are further divided into groups E, F, and G based on the type of combustible material. Most plastics, chemicals, wood, flours, and starches fall into category G. However, dust from aluminum and aluminum alloys and variations thereof, fall into category E with most metals.

Monitoring, Measuring and Management:

Listed below are some references from the NFPA and others for the management of combustible dust, in particular metal dusts in NFPA 484. In addition to outlining classifications and divisions for hazardous locations, these standards detail safe practices for handling of dusts, fire protection, venting, electricity, equipment, machinery, etc.

- **NFPA 61, "Standard for the Prevention of Fires and Dust Explosions in Agricultural and Food Products Facilities"**
- **NFPA 68, "Guide for Venting of Deflagrations"**
- **NFPA 69, "Standard on Explosion Prevention Systems"**
- **NFPA 77, "Recommended Practice on Static Electricity."**
- **NFPA 484, "Standard for Combustible Metals, Metal Powders, and Metal Dusts"**
- **NFPA 499, "Recommended Practice for the Classification of Combustible Dusts and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas"**.
- **NFPA 654, "Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing and Handling of Combustible Particulate Solids"**
- **OSHA Directive Number: CPL 03-00-008 - Combustible Dust National Emphasis Program**
- **FM Global 7-76 – Combustible Dust Explosion and Fire**

Recently, OSHA has established a National Emphasis Program to increase enforcement activities focusing on specific industry groups that have experienced frequent combustible dust incidents. OSHA initiated the Combustible Dust National Emphasis Program on October 18, 2007. Because of some recent accidents involving dust explosions, OSHA has decided to intensify its focus on this hazard. OSHA has begun to establish activities in the areas of outreach and training, specifically focused on providing employers with proper documentation, information, procedures, and resources needed to educate employers, while establishing cooperative ventures to enhance enforcement, protecting valued employees and assets.

According to OSHA, the purpose of the NEP is to inspect facilities that generate or handle these combustible dusts that could have potential for a deflagration or other fire hazards when suspended in air. Additionally, the initiative is intended to examine locations for the presence of any other oxidizing medium over a range of concentrations, regardless of particle size or shape, which can contribute to deflagrations, leading to explosions.

As stated by OSHA, situations where the facility that is being inspected is not a grain handling facility, citations under 29 CFR 1910.22 or 29 CFR 1910.176 can be issued if: (1) the lab results indicate that the dust is combustible, (2) the combustible dust accumulations are not contained within dust control systems or other containers, such as storage bins, that are adequate enough to prevent a deflagration, explosion, or other fire hazard. Additionally, for non-grain handling workplaces where combustible dust hazards exist within dust control systems or other containers, citations under section 5(a) (1) of the OSH Act can be issued for deflagration or explosion hazards. The NFPA standards listed in this section should be consulted to determine how to obtain evidence of a hazard(s) along with direction for establishing protection and prevention of dust explosions. OSHA states that if the workplace has a Class II location, then

citations under 29 CFR 1910.307 may be issued to employers having electrical equipment that do not meet standard requirements.

Good Housekeeping: Procedures and Devices

According to Chilworth Technology, Inc., the safe processing of flammable materials (dusts, gases or vapors) is facilitated by either preventing the conditions required for an explosion to occur, or protecting the plant and personnel from the effects of any such explosion. The combination of measures required to achieve such safe conditions is referred to as the "Basis of Safety". A "Basis of Safety" is the effective safeguards in place to manage explosion risks.

Just as in any industry, a formulation of a "Basis of Safety" can be established for the metallizing industry by adopting some good housekeeping initiatives. A few suggestions are listed below. **However, the NFPA standards and OSHA regulations should be followed accordingly to ensure proper handling and housekeeping of combustible dusts. By no means is the list below a recommended rule of thumb to follow.**

- Clean aluminum dust accumulations on a regular basis, making sure to document regular scheduled maintenance, while frequently checking the accumulations for explosibility
- Prevent the accumulation of the combustible aluminum dust from exceeding the thickness established by a ratio of the bulk density of the accumulation sample dust to wood dust
- Clean light aluminum dust accumulations by hand often to prevent suspension or the formation of an explosible dust cloud
- Utilization of approved vacuums is preferred over compressed air

cleaning to reduce the chance of generating a dust cloud

- Cleaning procedures should be carried out in a manner that ultimately minimizes the dispersion of the explosive aluminum combustible dust into the air – by doing this, the element of suspension is removed from the explosion pentagram – **follow NFPA standards**
- The approved equipment for cleaning, such as vacuum cleaners, should be properly rated for the classification of the location
 - Vacuums are typically industrial grade for typical wet/dry shop vacuums are not acceptable
- Vacuums utilized for cleaning used near machinery, equipment, or flammable substances should be rated for Class I, Division 1 or 2
- Vacuum cleaners utilized in locations classified as Class II, Division 1 or 2 areas like a metallizing facility, should be listed for use only in those designated areas
- Use proper dust collection systems and filters for aluminum dust, minimizing the escape of dust from process equipment or ventilation systems
- **Ultimately, follow NFPA standards for further recommendations on additional cleaning devices such as vacuums, building/location exhausters and indoor/outdoor dust collectors**

As provided by the CSB, OSHA recommends the following as a plan of action for the industry, which could be closely followed or modeled by employers to protect their employees from fire hazards and reduce the chances for explosible dust incidents:

- Issue a standard procedure to implement a hazardous dust inspection, housekeeping, testing,

- and control program to prevent combustible dust fires and explosions in general
- Base the standard procedure on current National Fire Protection Association (NFPA) dust explosion standards (including NFPA 654 and NFPA 484), and include at least:
 - hazard assessment
 - engineering controls
 - housekeeping
 - building design
 - explosion protection
 - operating procedures
 - worker training
 - Revise the internal standards and MSDS to include clarification on aluminum combustible dusts generated during the metallizing process, including those materials that may reasonably be anticipated to generate combustible dusts through downstream processing or handling
 - Establish and provide a training program making all employees aware of hazards present
 - Identify internal risks and establish an action plan to minimize risks

Ultimately, it is the responsibility of plant managers, engineers, maintenance associates, safety coordinators, and all associates to see that a policy is established for managing a hazardous environment and see that it is carried out on a daily basis to ensure the safety of all employees.

References:

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 - http://www.osha.gov/OshDoc/data_General_Facts/OSHAcombustibledust.pdf
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- National Fire Protection Agency (NFPA) Standards and Regulations
 - <http://www.nfpa.org/>
 - NFPA 61, "Standard for the Prevention of Fires and Dust Explosions in Agricultural and Food Products Facilities"

- NFPA 68, "Guide for Venting of Deflagrations"
- NFPA 69, "Standard on Explosion Prevention Systems"
- NFPA 77, "Recommended Practice on Static Electricity."
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- NFPA 654, "Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing and Handling of Combustible Particulate Solids"

- Exponent® Engineering and Scientific Consulting
 - <http://www.exponent.com/explosions/>

- Chilworth Technology, Inc.: A Professional Process Safety Firm. *Handling Dusts & Powders Safely: A Strategic Guide to Hazard Characterization & Understanding*. Chilworth Technology Inc. 250 Plainsboro Rd., Bldg. #7 Plainsboro, NJ 08536 Tel: 609 799 4449
 - www.chilworth.com