Industry Guide

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# A Guide to Combustible Dusts

NCDOL

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**This guide is intended to be consistent with all existing OSHA standards; therefore, if an area is considered by the reader to be inconsistent with a standard, then the OSHA standard must be followed instead of this guide.**

**To obtain additional copies of this guide, or if you have questions about North Carolina occupational safety and health standards or rules, please contact:**

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Additional sources of information are listed on the inside back cover of this guide.

The projected cost of the NCDOL OSH program for federal fiscal year 2011–2012 is $17,841,216. Federal funding provides approximately 31 percent ($5,501,500) of this total.

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# Contents

# Foreword

When most people think of controlling dust in the workplace, they think of taking steps to avoid inhaling dusts to prevent health problems. However, the accumulation of combustible dusts in the workplace can lead to far greater consequences. As seen in recent years, neglect of housekeeping and improper handling of combustible dusts can lead to property damage, injuries and loss of life.

*A Guide to Combustible Dusts* examines the sources of combustible dusts and the conditions necessary for a dust explosion to occur. This industry guide discusses how to assess dust hazards and how to mitigate those hazards. Particular attention is given to controlling dust, eliminating ignition sources and minimizing damage.

In North Carolina, the N.C. Department of Labor enforces the federal Occupational Safety and Health Act through a state plan approved by the U.S. Department of Labor. NCDOL offers many educational programs to the public and produces publications to help inform people about their rights and responsibilities regarding occupational safety and health.

When reading this guide, please remember the mission of the N.C. Department of Labor is greater than just regulatory enforcement. An equally important goal is to help citizens find ways to create safe workplaces. Everyone profits when managers and employees work together for safety. This booklet, like the other educational materials produced by the N.C. Department of Labor, can help.

Cherie Berry
Commissioner of Labor

# Introduction

In industry, dust is generated as a by-product of several processes that include material conveying, crushing and screening, sanding, and trimming of excess material. The creation of dust does not necessarily pose a safety and health risk. However, where combustible dust is produced and allowed to accumulate, it can lead to catastrophic consequences.

In recent years, combustible dust explosions have resulted in the loss of life, multiple injuries and substantial property damage. In May 2002, an explosion at Rouse Polymerics International, a rubber fabricating plant in Vicksburg, Miss., injured 11 employees, five of whom later died of severe burns. The explosion occurred with the ignition of an accumulation of a highly combustible rubber.

An explosion and fire occurred on Jan. 29, 2003, at the West Pharmaceutical Services plant in Kinston, N.C. This catastrophe resulted in the deaths of six workers, injury to dozens of employees, and job losses to hundreds due to destruction of the plant. The facility produced rubber stoppers and other products for medical use. The fuel for the explosion was a fine plastic powder that had accumulated unnoticed above a suspended ceiling over the manufacturing area.

On Feb. 20, 2003, an explosion and fire damaged the CTA Acoustics manufacturing plant in Corbin, Ky., fatally injuring seven employees. The facility produced fiberglass insulation for the automotive industry. The combustible dust involved was a phenolic resin binder used in producing fiberglass mats.

On the evening of Oct. 29, 2003, a series of explosions severely burned three employees, one fatally, and caused property damage to the Hayes Lemmerz manufacturing plant in Huntington, Ind. The Hayes Lemmerz plant manufactured cast aluminum automotive wheels, and the explosions were fueled by aluminum dust, a combustible by-product of the production process.

Combustible sugar dust was the fuel for a massive explosion and fire that occurred Feb. 7, 2008, at the Imperial Sugar Co. plant in Port Wentworth, Ga., resulting in 13 deaths and the hospitalization of 40 more workers, some of whom received severe burns.

These explosions—in Michigan, Mississippi, North Carolina, Kentucky, Indiana and Georgia—resulted in the loss of 32 lives and caused numerous injuries and substantial property losses.

In North Carolina, between April 1988 and February 2006, 17 employers experienced combustible dust explosions during which 76 employees were injured, nine of whom died. An additional 20 safety and health inspections were conducted at other locations where combustible dust hazards were identified.

# 1

# Types of Combustible Dust

## *What Is Dust?*

Dust is defined as "solid particles generated by handling, crushing, grinding, rapid impact, detonation, and decrepitation of organic or inorganic materials, such as rock, ore, metal, coal, wood, and grain."[1] A wide range of particle sizes is produced during a dust-generating process. Particles that are too large to remain airborne settle out, while the smallest ones remain suspended in air indefinitely.

Dusts are measured in micrometers (commonly known as microns or µm). The micrometer is a unit of length equal to $10^{-4}$ (0.0001) centimeter or approximately 1/25,000 of an inch. Red blood cells are 8 µm (0.0008 cm) in size; human hair is 50–75 µm in diameter and cotton fiber, 15–30 µm.

## *What Distinguishes a Combustible Dust From Other Dusts?*

The National Fire Protection Association (NFPA) defines a *combustible dust* as "a combustible particulate solid that presents a fire or deflagration hazard when suspended in air or some other oxidizing medium over a range of concentrations, regardless of particle size or shape."[2] In general, combustible particulates having an effective diameter of 420 µm or smaller, as determined by passing through a U.S. No. 40 Standard Sieve, are generally considered to be combustible dusts. However, agglomerates of combustible materials that have lengths that are large compared to their diameter (and will not usually pass through a 420 µm sieve) can still pose a deflagration hazard. Therefore, any particle that has a surface area to volume ratio greater than that of a 420 µm diameter sphere should also be considered a combustible dust.[2]

The vast majority of natural and synthetic organic materials, as well as some metals, can form combustible dust. The NFPA's Industrial Fire Hazards Handbook[3] states, "any industrial process that reduces a combustible material and some normally noncombustible materials to a finely divided state presents a potential for a serious fire or explosion."

Some of the natural and synthetic organic materials that can form combustible dusts include:

- Food products (e.g., grain, cellulose, powdered milk, sugar, flour, starch, cocoa, maltodextrin)
- Pharmaceuticals (e.g., vitamins)
- Wood (e.g., wood dust, wood flour )
- Textiles (e.g., cotton dust, nylon dust)
- Plastics (e.g., phenolics, polypropylene)
- Resins (e.g., lacquer, phenol-formaldehyde)
- Biosolids (dried wastes from sewage treatment plants)
- Coal and other carbon dusts

Combustible dusts can also be formed from inorganic materials and metals including:

- Aluminum
- Iron
- Magnesium powder
- Manganese
- Sulfur

## *What Industries Are at Risk?*

Combustible dust explosion hazards exist in a variety of industries, including:

- Agriculture
- Chemicals
- Food (e.g., candy, sugar, spice, starch, flour, feed)
- Grain elevators, bins and silos
- Fertilizer

- Tobacco
- Plastics
- Wood processing and storage
- Furniture
- Paper
- Tire and rubber manufacturing
- Textiles
- Pharmaceuticals
- Metal powder processing or storage (especially magnesium and aluminum)

# 2

# Elements of a Dust Explosion

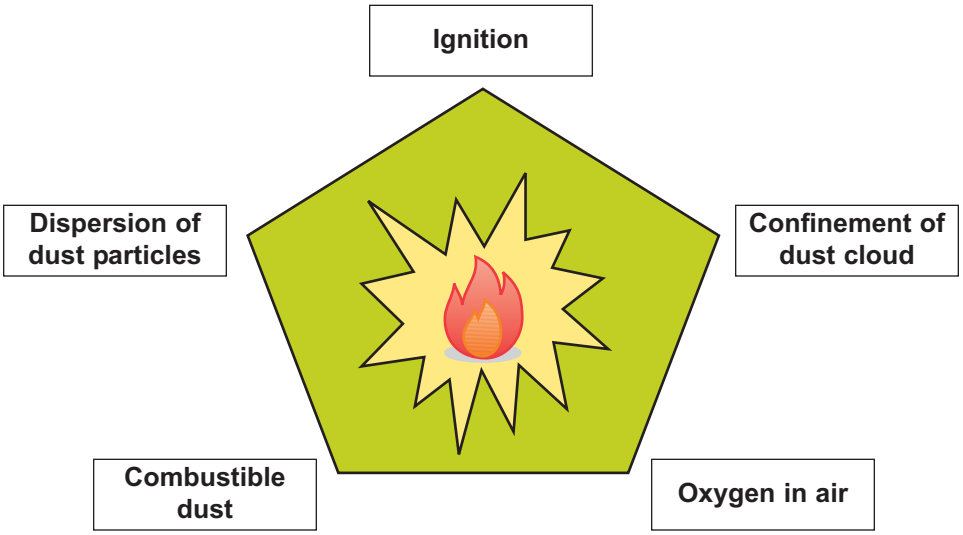
For a combustible dust explosion to occur, the necessary elements for a fire must be present ("fire triangle"). The elements are:

- a fuel source (combustible dust);
- a heat or ignition source (e.g., electrostatic discharge, an electric current arc, a glowing ember, a hot surface, welding slag, frictional heat, or a flame); and
- an oxidizer (oxygen in the air).

The presence of two additional elements makes conditions favorable for a combustible dust explosion. The first is the dispersal of dust particles into the air in sufficient quantity and concentration to create a dust cloud. The second is the confinement (or semi-containment) of the dust cloud in a vessel, area, building, room or process equipment. When ignited, the dust cloud will burn rapidly and may explode. The combination of these five elements comprises what is referred to as the "dust explosion pentagon" (see Figure 1).

**Figure 1**

***Dust Explosion and Explosion Pentagon***




## *How Dust Explosions Occur*

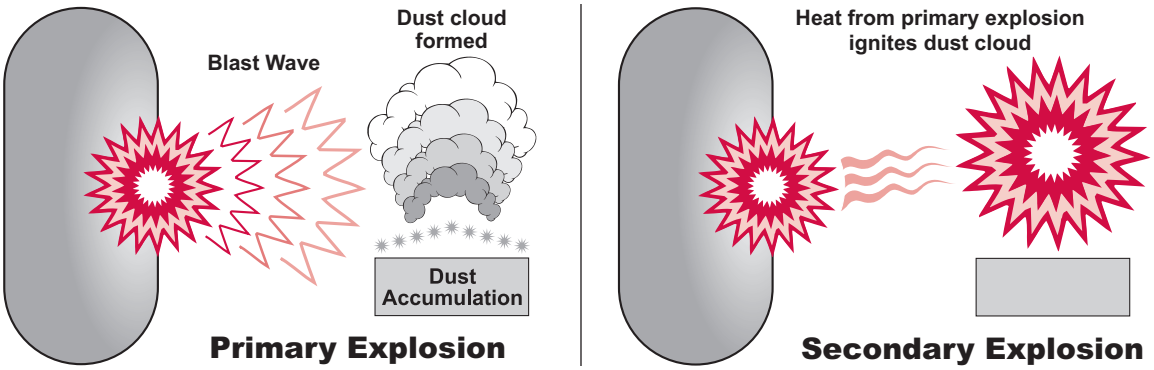
When all of these elements are in place, rapid combustion known as *deflagration* (a rapid burning slower than the speed of sound) can occur. If this event is confined by an enclosure, such as a building, room, vessel or process equipment, the resulting pressure rise can cause an *explosion* (a rapid burning faster than the speed of sound).

## *Secondary Explosions Are Catastrophic*

An initial (primary) explosion (see Figure 2) in processing equipment or in areas where fugitive dust has accumulated may dislodge additional dust or damage a collection system (such as a duct, vessel or collector). This dust, if ignited, causes additional explosions, which can result in damage that is more severe than the original explosion due to increased concentrations and quantities of dispersed combustible dust.

**Figure 2**

***Combustible dust explosion***



# 3

# Facility Dust Hazard Assessment

As previously stated, a combustible dust hazard can exist in a variety of industries, including food, plastics, wood, rubber, furniture, textiles, pharmaceuticals, dyes, coal, metals, and fossil fuel generation.

When conducting a hazard assessment of the facility for combustible dust explosion hazards, employers should identify the following:

- ♦ Materials that can become combustible when they are finely milled
- ♦ Processes that use or produce combustible dusts
- ♦ Open areas where combustible dusts may accumulate
- ♦ Hidden areas where combustible dusts may accumulate
- ♦ Means by which dust can be dispersed in the air
- ♦ Potential ignition sources

## *Dust Combustibility*

The primary factor in assessing the potential for dust explosion hazards is the combustibility of the dust. Again, a combustible dust is characterized by the ability of the material to pass through a U.S. No. 40 Standard Sieve, i.e., it is 420 µm or smaller in diameter and presents a fire or explosion hazard when dispersed in air and ignited. One possible source of information on the combustibility of the material is the Safety Data Sheet (SDS).

Different dusts of the same chemical material will have different ignitability and explosibility characteristics, depending on particle size, particle shape and moisture content. In addition, these characteristics can change while the material is passing through process equipment.

## *Electrical Classification*

The facility hazard assessment must also identify areas requiring special electrical equipment due to the presence, or potential presence, of combustible dust. The OSHA electrical standards (29 CFR 1910, Subpart S) contain general requirements for electrical installations in hazardous areas. Specifically, 1910.307 covers the requirements for electric equipment and wiring in locations that are considered "classified." These classifications depend on (1) the properties of flammable vapors, liquids or gases, or combustible dusts or fibers that may be present, and (2) the likelihood that a flammable or combustible concentration or quantity is present. Areas where the hazard of combustible dust is present are classified as Class II locations.

Class II locations are further classified into Division 1 and Division 2 locations depending upon the likelihood of the dust being suspended or dispersed in the air under normal conditions. (See Glossary for specific definitions of Class II, Division 1 and Division 2 locations.) Combustible dust locations are even further classified into Groups E, F and G according to the type of combustible dust and its properties.

- Group E atmospheres contain combustible metal dusts. These include aluminum, magnesium (and their commercial alloys) or other combustible dusts whose particle size, abrasiveness and conductivity present similar hazards in the use of electrical equipment. Certain metal dusts may have characteristics that require additional safeguards. Examples include zirconium, thorium and uranium dusts, which have very low ignition temperatures.
- Group F atmospheres contain carbon dusts that have more than 8 percent total entrapped volatiles or have been sensitized by other materials so that they present an explosion hazard. Examples include coal, carbon black, coke dusts and charcoal.
- Group G atmospheres contain combustible dusts not included in Group E or F. These include flour, grain, wood, plastic and chemicals.

## *Other Hazard Analysis Considerations*

Because a variety of conditions can affect the amount of combustible dust needed to reach an explosive concentration, the employer should make the hazard analysis specific for each facility. Variables to consider include the size of the dust particles, the method of dispersing dust in the air, ventilation systems, air currents, humidity, physical barriers, and the volume of the area in which the dust cloud exists or could potentially exist.

The facility hazard assessment should consider all locations where combustible dust is concentrated during normal equipment operation as well as in the event of equipment failure. In addition, the assessment should cover areas where dust can settle, both in normally occupied areas and in hidden concealed spaces. The NFPA considers areas with as little as 1/32 inch of combustible dust accumulation on greater than 5 percent of floor areas (including overhead beams and sills) to be a significant explosion risk. (Reference 2.)

After the combustible dust hazards have been assessed and the hazardous locations identified, any or all of the prevention, protection and mitigation methods discussed in Part 4 may be applied.

# 4

# Hazard Mitigation

## *Dust Control*

Some of the recommendations found in NFPA 654 (see Reference 2) for the control of dusts to prevent explosions include the following:

- Minimize the escape of dust from process equipment or ventilation systems.
- Use dust collection systems and filters.
- Use surfaces that reduce dust accumulation and help with cleaning.
- Provide access to all hidden areas to permit inspection.
- Conduct regular inspections for dust in open and hidden areas.
- Clean dust residues at regular intervals.
- Use cleaning methods that do not generate dust clouds if ignition sources are present (e.g., do not use compressed air).
- Use vacuum cleaners only if approved (e.g., UL, FM) for combustible dust collection.
- Locate relief valves away from dust hazard areas.
- Develop and implement a written program for hazardous dust inspection, housekeeping and control.

## *Ignition Control*

NFPA 654 also contains guidance on the control of ignition sources to prevent dust explosions, including the following:

- Use appropriate electrical equipment and wiring methods.
- Control static electricity, including bonding of equipment to ground.
- Control smoking, open flames and sparks.
- Control friction and mechanical sparks.
- Use separator devices to remove foreign materials capable of igniting combustibles from process materials.
- Separate heated surfaces from dusts.
- Separate heating systems from dusts.
- Use industrial trucks of the proper type.
- Use cartridge activated tools properly.
- Adequately maintain all of the above equipment.

The proper electrical equipment must be used in hazardous locations to eliminate or control sparking, a common ignition source. Special Class II wiring methods and equipment (such as “dust ignition-proof” and “dust-tight”) must be used as required by 29 CFR 1910.307 and in NFPA 70 Article 500.

Additionally, the employer should put into effect a hot work permit system that effectively addresses how hot work (welding, cutting, grinding, etc.) is to be performed on and around ventilation ductwork and in areas where combustible dust may accumulate.

## *Damage Control*

Some of the protection methods suggested in NFPA 654 to minimize the danger and damage resulting from an explosion are the following:

- Separation of the hazard (isolate with distance).
- Segregation of the hazard (isolate with a barrier).
- Deflagration venting of a building, room or area.
- Pressure relief venting for equipment.
- Provision of spark/ember detection and extinguishing systems.
- Explosion protection systems.

- Sprinkler systems.
- The use of other specialized suppression systems.

## *Dust Handling Equipment*

Some of the types of equipment that are used in dust handling, and which have been involved in dust explosions, are bag openers (slitters), blenders and mixers, dryers, dust collectors, pneumatic conveyors, size reduction equipment (grinders), silos and hoppers, hoses, loading spouts, and flexible boots.

Blenders and mixers create a dust atmosphere due to solids rubbing together. This tumbling of solids also creates frictional heat, an ignition source. An additional ignition source arises from the electrostatic charging of the solids due to the solids rubbing together. Finally, there is the heating of the equipment itself, due to the energy involved in mixing the materials.

Material dryers provide a source of heat either through direct heating or indirect heating. Direct-heat dryers provide heat either by heated air or gas. Moisture is carried away by the drying medium. Indirect-heat dryers use either heat transfer by conduction or steam (for jacketed dryers) to transfer heat to the material and to drive off the moisture.

Dust collector fabric filters (baghouses) are characterized by the presence of an easily ignitable fine dust atmosphere and high turbulence. The bag filters are often not kept clean or in good condition, which can also result in fires. Electrostatic spark discharges occur which can act as an ignition source. In some processes, hot, glowing particles may enter the baghouse from upstream equipment and can act as an ignition source.

In pneumatic conveying systems, equipment located downstream can be at high risk for fires and explosions. Contact of the dust particles with other particles and the duct walls generates a static electricity discharge. Heated particles created during grinding or drying and carried into the system can be fanned to a glow by the movement of high velocity air.

When grinding or milling, ignition is possible from friction heat and the hot surfaces that result from grinding. Of additional concern is a slow feed rate that can increase the possibility of a fire or explosion hazard.

# 5

# Training

## *Employees*

Workers are the first line of defense in preventing and mitigating fires and explosions. If the people closest to the source of the hazard are trained to recognize and prevent the hazards of combustible dust in the facility, they can recognize unsafe conditions, take preventative action and alert management.

While OSHA standards require employers to conduct task-specific training for affected employees (such as forklift driving), all employees should be trained in safe work practices that are applicable to their job tasks. In addition, employees should be trained on facility-wide programs, which would include those for dust and ignition source control. Employees should be trained on work place hazards before they begin work, periodically as refresher training, whenever reassigned, and when hazards or processes change.

Employers with hazardous chemicals, which include combustible dusts, are required to comply with the Hazard Communication Standard, 29 CFR 1910.1200. This must include proper labeling of hazardous chemical containers, the collection and use of SDSs, and employee training.

## *Management*

A qualified team of managers should be responsible for conducting a facility analysis (or having one done by qualified outside persons) to develop a prevention and protection plan tailored to their operation. A review of plan changes should be done prior to the introduction of a new hazard or process. Supervisors and managers should be aware of and support the plant dust and ignition control programs. Their training should include how to encourage employees to report unsafe practices and how to make abatement actions possible.

# 6

# Combustible Dust in the Industry Guide Series

The Industry Guide series focuses on a variety of hazards to which employees working in a range of industrial processes are potentially exposed. Combustible dust hazards, in particular, have been discussed in association with wood dust in wood processing and furniture manufacturing (Industry Guide #19, *A Guide to Occupational Exposure to Wood, Wood Dust and Combustible Dust Hazards*) and grain dust in feed and grain mills (Industry Guide #29, *A Guide to Safety and Health in Feed and Grain Mills*).

Some of the questions that employers who are involved in wood processing and storage should ask themselves as part of their wood dust hazard assessment (see Part 3 of this industry guide) are:

- Has the possibility of wood dust decay and the heat associated with decay been addressed as a possible source of ignition?
- Is combustible wood dust routinely removed from elevated surfaces including the overhead structure of buildings, false ceiling, shelves, etc.?

The consequence of grain dust explosions have been well documented and is the basis for the OSHA standard on grain handling facilities, 29 CFR 1910.272. The conditions under which a grain dust explosion occurs result from the following:

- A complex combination of dust particle sizes
- The concentration of dust particles in the air
- The energy of the ignition source
- The moisture content of the dust (or percent of relative humidity of the air)
- The actual composition of the dust

When these conditions are present and the concentration of suspended dust exceeds the lower explosive limits of that particular dust, an explosion results.

Table 1 indicates that various grains have different explosive properties. When dusts generated from grains are not properly handled, the conditions for an explosion can develop.

**Table 1**

***Explosive Properties of Common Grain Dusts***

| Type of Dust | Maximum Pressure (kPA)[1] | Maximum Rate of Pressure Rise (MPa/s)[2] | Ignition Temperature | | Maximum Ignition Energy (J)[5] | Lower Explosive Limit (g/m³)[6] |
|---|---|---|---|---|---|---|
| | | | Cloud (°C)[3] | Layer (°)[4] | | |
| Alfalfa | 455 | 7.6 | 460 | 200 | 0.32 | 100 |
| Cereal grass | 360 | 3.5 | 550 | 220 | 0.80 | 200 |
| Corn | 655 | 41.0 | 400 | 250 | 0.04 | 55 |
| Flax shive | 560 | 5.5 | 430 | 230 | 0.08 | 80 |
| Grain dust, winter wheat, corn, oats | 790 | 38.0 | 430 | 220 | 0.03 | 55 |
| Rice | 640 | 18.0 | 440 | 220 | 0.05 | 50 |
| Soy flour | 540 | 5.5 | 540 | 190 | 0.10 | 60 |
| Wheat flour | 655 | 26.0 | 380 | 360 | 0.05 | 50 |
| Wheat straw | 680 | 41.0 | 470 | 220 | 0.05 | 55 |

*Source: U.S. Bureau of Mines 1961.*
This table is presented only to illustrate that grains are of varying volatility; it is not offered as a formula for calculations.
[1](kPA) is a symbol representing the maximum pressure rise.
[2](MPa/s) is a symbol representing the rate of pressure rise.
[3](°C) is a symbol for cloud where the auto-ignition in a combustible cloud is measured in degrees Celsius.
[4](°) is a symbol for layer where the layer ignition temperature is measured in degrees Celsius.
[5]J is the symbol for the minimum ignition energy of a combustible mixture.
[6](g/m³) is the symbol for the lower explosive limit of a given dust.

When grain is moved, grain dust is produced. The more that the grain is handled, the more dust is produced. The more dust produced in a confined space, the greater the chance of exceeding the lower explosive limit of the dust. The more the lower explosive limit is exceeded, the greater the likelihood of an explosion. As shown in Table 1, each type of grain and the dust it produces has its own lower explosive limit.

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# Standards Applicable to Combustible Dusts

## *NCDOL*

**General Industry**

- ♦ 1910.22, Housekeeping
- ♦ 1910 Subpart E, Means of Egress
- ♦ 1910.94, Ventilation
- ♦ 1910.119, Process Safety Management
- ♦ 1910.145, Warning Signs
- ♦ 1910.146, Permit-Required Confined Spaces
- ♦ 1910.176, Handling Materials
- ♦ 1910.178, Powered Industrial Trucks
- ♦ 1910.252, Welding, Cutting and Brazing
- ♦ 1910 Subpart R, Special Industries
  - o 1910.263, Bakery Equipment
  - o 1910.265, Sawmills
  - o 1910.269, Electric Power Generation, Transmission and Distribution
  - o 1910.272, Grain Handling Facilities
- ♦ 1910.307, Hazardous (Classified) Locations
- ♦ 1910.1200, Hazard Communication

**N.C. General Statute § 95-129(1)**—*General Duty Clause*

## *National Consensus*

*Note:* These are not NCDOL regulations. However, they do provide guidance from their originating organizations related to worker protection.

**National Fire Protection Association (NFPA)**

- ♦ NFPA 61, Standard for the Prevention of Fires and Dust Explosions in Agricultural and Food Processing Facilities
- ♦ NFPA 68, Guide for Venting of Deflagrations
- ♦ NFPA 70, National Electrical Code
- ♦ NFPA 77, Recommended Practice on Static Electricity
- ♦ NFPA 484, Standard for Combustible Metals
- ♦ NFPA 654, Standard for the Prevention of Fires and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids
- ♦ NFPA 655, Standard for Prevention of Sulfur Fires and Explosions
- ♦ NFPA 664, Standard for the Prevention of Fires and Explosions in Wood Processing and Woodworking Facilities

# 8

# Glossary

*Agglomerates*. Clusters of particles adhering to one another.

*Class II location*. These locations are hazardous due to the presence of combustible dust.

(1) *Class II, Division 1*. A Class II, Division 1 location is a location:
   (i) In which combustible dust is or may be in suspension in the air under normal operating conditions, in quantities sufficient to produce explosive or ignitable mixtures; or
   (ii) Where mechanical failure or abnormal operation of machinery or equipment might cause such explosive or ignitable mixtures to be produced, and might also provide a source of ignition through simultaneous failure of electric equipment, through operation of protection devices, or from other causes; or
   (iii) In which combustible dusts of an electrically conductive nature may be present.

(2) *Class II, Division 2*. A Class II, Division 2 location is a location where:
   (i) Combustible dust is not normally suspended in the air in quantities that are sufficient to produce explosive or ignitable mixtures, and dust accumulations will normally be insufficient to interfere with the normal operation of electric equipment of other apparatus, but combustible dust may be in suspension in the air as a result of infrequent malfunctioning of handling or processing equipment; and
   (ii) Resulting combustible dust accumulations on, in or near the electric equipment may be sufficient to interfere with the safe dissipation of heat from electric equipment or may be ignitable by abnormal operation or failure of electric equipment.

*Decrepitation*. Decrepitation is the breaking of a substance usually accompanied by the emission of a crackling sound.

*Deflagration*. Rapid combustion without the generation of a shock wave. A combustion reaction in which the velocity of the reaction front through the unreacted fuel medium is less than the speed of sound. (NFC On-line glossary)

*Deflagration hazard*. A situation where deflagrable combustible dust is normally in suspension or can be put in suspension at concentration at or above the minimum explosible concentration (MEC).

*Detonation*. Propagation of a combustion zone at a velocity greater than the speed of sound in the unreacted medium.

*Explosion*. The bursting or rupture of an enclosure or a container due to the development of internal pressure from deflagration.

*Fugitive dust*. Any dust that is lost from manufacturing or other processes.

*Lower explosive limit (LEL).* The concentration of a compound in air below which the mixture will not catch on fire.

*Minimum explosible concentration (MEC).* The minimum concentration of combustible dust suspended in air, measured in mass per unit volume that will support deflagration. The MEC can be determined using the test procedure in ASTM E 1515, Standard Test Method for Minimum Explosible Concentration of Combustible Dusts.

*Minimum ignition temperature (MIT).* The lowest temperature at which ignition occurs. The smaller the particle size, the lower the MIT; the lower the moisture content, the lower the MIT.

# 9

# References

1. National Safety Council. *Fundamentals of Industrial Hygiene*, 3rd Edition. National Safety Council. Chicago, Ill. 1988.

2. National Fire Protection Association (NFPA). NFPA 654. *Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids*. 2006 Edition NFPA Inc. Quincy, Mass. 2006. http://www.nfpa.org

3. National Fire Protection Association (NFPA). *Industrial Fire Hazards Handbook*, 3rd Edition. NFPA Inc. Quincy, Mass. 1990.

# Appendix A

## Products and Materials That Form Combustible Dusts

**Agricultural Products**
Egg white
Milk, powdered
Milk, nonfat, dry
Soy flour
Starch, corn
Starch, rice
Starch, wheat
Sugar
Sugar, milk
Sugar, beet
Tapioca
Whey
Wood flour

**Agricultural Dusts**
Alfalfa
Apple
Beet root
Carrageen
Carrot
Cocoa bean dust
Cocoa powder
Coconut shell dust
Coffee dust
Corn meal
Corn starch
Cotton
Cottonseed
Garlic powder
Gluten
Grass dust
Green coffee
Hops (malted)
Lemon peel dust
Lemon pulp
Linseed
Locust bean gum
Malt
Oat flour
Oat grain dust
Olive pellets
Onion powder
Parsley (dehydrated)
Peach
Peanut meal and skins
Peat
Potato
Potato flour
Potato starch
Raw yucca seed dust
Rice dust
Rice flour
Rice starch
Rye flour
Semolina
Soybean dust
Spice dust
Sugar (10x)
Sunflower
Sunflower seed dust
Tea
Tobacco dust
Tomato
Walnut dust
Wheat flour
Wheat grain dust
Wheat starch
Xanthan gum

**Carbonaceous Dusts**
Charcoal, activated
Charcoal, wood
Coal, bituminous
Coke, petroleum
Lampblack
Lignite
Peat, 22% $H_2O$
Soot, pine
Cellulose
Cellulose pulp
Cork
Corn

**Chemical Dusts**
Adipic acid
Anthraquinone
Ascorbic acid
Calcium acetate
Calcium stearate
Carboxy-methyl cellulose
Dextrin
Lactose
Lead stearate
Methyl cellulose
Paraformaldehyde
Sodium ascorbate
Sodium stearate
Zinc stearate

**Metal Dusts**
Aluminum
Bronze
Iron carbonyl
Magnesium
Zinc

**Plastic Dusts**
(poly) Acrylamide
(poly) Acrylonitrile
(poly) Ethylene (low pressure process)
Epoxy resin
Melamine resin
Melamine, molded (phenol-cellulose)
Melamine, molded (wood flour and mineral filled phenol-formaldehyde)
(poly) Methyl acrylate
(poly) Methyl acrylate, emulsion polymer
Phenolic resin (poly) Propylene
Terpene-phenol resin
Urea-formaldehyde/ cellulose, molded
(poly) Vinyl acetate/ethylene copolymer
(poly) Vinyl alcohol
(poly) Vinyl butyral
(poly) Vinyl chloride/ethylene/vinylacetylene suspension copolymer
(poly) Vinyl chloride/vinylacetylene emulsion copolymer

## OSH Publications

We provide a variety of OSH publications. These include general industry and construction regulations, industry guides that cover different OSH topics, quick cards, fact sheets and brochures that cover a wide variety of serious safety and health workplace hazards. Workplace labor law posters are available free of charge. To obtain publications, call toll free at 1-800-NC-LABOR (1-800-625-2267) or direct at 919-707-7876. You may view the list of publications and also download many of them at **www.labor.nc.gov/safety-and-health/publications**.

# Occupational Safety and Health (OSH)
## Sources of Information

**You may call 1-800-NC-LABOR (1-800-625-2267) to reach any division of the N.C. Department of Labor (NCDOL); or visit the NCDOL website at: www.labor.nc.gov.**

**Occupational Safety and Health Division**

Mailing Address:
1101 Mail Service Center
Raleigh, NC 27699-1101

Physical Location:
111 Hillsborough St.
(Old Revenue Building, 3rd Floor)

Local Telephone: 919-707-7806 Fax: 919-807-2856

*For information concerning education, training, interpretations of occupational safety and health standards, and OSH recognition programs contact:*

**Education, Training and Technical Assistance Bureau**

Mailing Address:
1101 Mail Service Center
Raleigh, NC 27699-1101

Physical Location:
111 Hillsborough St.
(Old Revenue Building, 4th Floor)

Telephone: 919-707-7876 Fax: 919-807-2876

*For information concerning occupational safety and health consultative services contact:*

**Consultative Services Bureau**

Mailing Address:
1101 Mail Service Center
Raleigh, NC 27699-1101

Physical Location:
111 Hillsborough St.
(Old Revenue Building, 3rd Floor)

Telephone: 919-707-7846 Fax: 919-807-2902

*For information concerning migrant housing inspections and other related activities contact:*

**Agricultural Safety and Health Bureau**

Mailing Address:
1101 Mail Service Center
Raleigh, NC 27699-1101

Physical Location:
111 Hillsborough St.
(Old Revenue Building, 2nd Floor)

Telephone: 919-707-7820 Fax: 919-807-2924

*For information concerning occupational safety and health compliance contact:*

**Safety and Health Compliance District Offices**

**Raleigh District Office** (3801 Lake Boone Trail, Suite 300, Raleigh, NC 27607)
Telephone: 919-779-8570 Fax: 919-420-7966

**Asheville District Office** (204 Charlotte Highway, Suite B, Asheville, NC 28803-8681)
Telephone: 828-299-8232 Fax: 828-299-8266

**Charlotte District Office** (901 Blairhill Road, Suite 200, Charlotte, NC 28217-1578)
Telephone: 704-665-4341 Fax: 704-665-4342

**Winston-Salem District Office** (4964 University Parkway, Suite 202, Winston-Salem, NC 27106-2800)
Telephone: 336-776-4420 Fax: 336-767-3989

**Wilmington District Office** (1200 N. 23rd St., Suite 205, Wilmington, NC 28405-1824)
Telephone: 910-251-2678 Fax: 910-251-2654

****To make an OSH Complaint,* **OSH Complaint Desk:** 919-779-8560***

*For statistical information concerning program activities contact:*

**Planning, Statistics and Information Management Bureau**

Mailing Address:
1101 Mail Service Center
Raleigh, NC 27699-1101

Physical Location:
111 Hillsborough St.
(Old Revenue Building, 2nd Floor)

Telephone: 919-707-7838 Fax: 919-807-2951

*For information about safety videos, labor-related books or electronic resources contact:*

**N.C. Department of Labor Library**

Mailing Address:
1101 Mail Service Center
Raleigh, NC 27699-1101

Physical Location:
111 Hillsborough St.
(Old Revenue Building, 5th Floor)

Telephone: 919-707-7880 Fax: 919-807-2849

**N.C. Department of Labor (Other than OSH)**

1101 Mail Service Center
Raleigh, NC 27699-1101
Telephone: 919-707-7766 Fax: 919-733-6197