Reducing Sawdust Combustion Potential

Issue

Combustible Dust Explosion Kills 13

"An explosion at Imperial Sugar's plant in Port Wentworth, Georgia, US on 7th February erupted when combustible sugar dust inside the plant ignited like gunpowder. The blast killed 13 people and injured dozens more. Six workers remain hospitalized over a month later with severe burns, three of them in critical condition. About 12 percent of the plant, which produces Dixie Crystals brand sugar, was destroyed." [1]

This excerpt from an article about a devastating explosion that occurred at the Imperial Sugar refinery and highlights the potential hazard that exists when manufacturing operations produce combustible dust. The manufacturing of wood trusses and wall panels is no exception, and manufacturers need to understand dust issues and take the necessary precautions to ensure fire protection and employee safety due to combustible dust hazards. This issue is particularly important due to the recent increased focus of the Occupational Safety & Health Administration (OSHA).

Discussion and Recommendation

After a recent rise in industrial combustible dust explosions in this country, the U.S. Chemical Safety Board (CSB) strongly urged OSHA to issue new rules regarding the regulation of combustible dust in the workplace. As a first step, on October 18, 2007, OSHA released an expanded National Emphasis Program (NEP) on Combustible Dust. Under this NEP, OSHA has plans to conduct over 300 additional combustible dust inspections each year.

One of the major contributors to the risk of an explosion is the size of the dust particles**.** Fine particles that more easily suspend in the air carry a greater risk of explosion than do larger particles. These finer particles are more likely to be generated by sanding operations than by cutting or milling operations. However, even cutting and milling can generate a small percentage of fine wood dust that, if allowed to accumulate over time, could be potentially hazardous.

The devastating Imperial Sugar explosion in Georgia prompted two members of Congress to introduce the "Combustible Dust Explosion and Fire Prevention Act" (H.R. 5522). This Act will force OSHA to issue a new rule on combustible dust, requiring manufacturers to comply with combustible dust standards created by the National Fire Prevention Association (NFPA). These standards, which are currently voluntary, would become mandatory. This would significantly alter the way in which combustible dusts (like wood dust) will have to be collected and disposed. While the outcome of this legislation is not certain, both truss manufacturing and engineered wood manufacturing are listed as targeted industries by OSHA's new Combustible Dust NEP. As such, it is important for truss manufacturer's to be aware of the requirements of the NFPA standard.

Component manufacturers can benefit from focusing on the following NFPA guidelines intended to lower the risk of a dust explosion. All NFPA standards referred to in this document can be found in their entirety in the Appendix at the end.

NFPA 664, 7.10.1 recommends that;
7.10.1 Feed-Rate Controls (Hot Cuts.) Feed rates and machine adjustments for the stock being processed on wood cutting, shaping, planing and sanding operations shall be controlled to prevent ignition.

To be more specific, in Section 7.10.2.1, it clarifies that;
7.10.2.1 Wood cutting, shaping and planing equipment shall be maintained at a level of sharpness to minimize the heat generated from woodworking operations.

In NFPA 499, Table 4.5.2, wood flour is listed as a NEC Group G combustible material that requires an ignition temperature of 250 degrees Celsius (482 degrees Fahrenheit). Saw blades should be maintained (sharpened) in a condition such that heat buildup due to friction is minimized.

Another potential heat source is a lit cigarette. NFPA 664, Section 10.10, recommends that;
10.10 Smoking. Smoking shall be permitted only in designated areas equipped with ample devices for smoking material disposal and free of combustible/flammable hazards or storage.
In other words, smoking should not be allowed near component saws or areas where wood dust is collected and stored for disposal.

With regard to management and disposal of wood dust in your production facility, NFPA 664, Section 11.1, provides good general requirements:
11.1.2 Documented housekeeping and inspection programs shall be developed and maintained.
11.1.3 Any waste material or debris found in large enough quantity that the machinery is heavily coated or is in any way impeding the operation of energized or moving equipment shall be collected and removed immediately.
11.1.4 Combustible waste that cannot be reintroduced to the production process or utilized for fuel shall be placed in covered metal receptacles until removed to a safe place for daily disposal.
11.1.6 Production equipment shall be maintained and operated in a manner that minimizes the escape of debris or dust.
11.1.7 Spaces inaccessible to housekeeping shall be sealed to prevent dust accumulation.

To summarize these points, to be fully prepared for an OSHA inspection on combustible dust, a documented wood dust housekeeping plan is needed. The plan should address how to collect and dispose of the wood dust wood cutting operations generate. It should also document how often wood dust will be cleaned up to ensure that it does not accumulate above the 1/32-inch threshold mentioned previously.

If the wood dust collection system includes a "baghouse," or cyclone collection system, make sure that the housekeeping plan includes regular and thorough cleaning of this equipment. If a conveyer or manual wood waste collection system is used, ensure that final storage and disposal receptacles are made out of metal and can be fully enclosed (with a lid or other device). Those bins should not be allowed to overflow, so timely collection needs to be a part of the overall plan.

Finally, a thorough facility inspection should indicate that there are no inaccessible or enclosed spaces that have the potential for collecting fine wood flour particles. Any concerns about sawdust levels in the facility should be brought to the attention of your property/casualty insurance carrier, where they can provide counsel on air sample testing that would document sawdust generation capacity to help control and manage explosion risk.

Appendix 1

Analysis

The National Fire Protection Association (NFPA) is an international membership organization that develops voluntary consensus codes and standards that are adopted by state and local jurisdictions throughout the U.S. NFPA code language is predominately fire prevention focused and is the language referenced in H.R. 5522, the "Combustible Dust Explosion and Fire Prevention Act".

Combustible Dust

NFPA Standard 499, *Recommended Practice for the Classification of Combustible Dusts and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas*, Section 3.3.3., defines combustible dust as;
3.3.3 Any finely divided solid material that is 420 microns or smaller in diameter (material passing a U.S. No. 40 Standard Sieve) and presents a fire or explosion hazard when dispersed or ignited in air.
By comparison, a human hair is on average 0.004 inches, 420 microns is 0.0165 inches, so a combustible wood dust particle is about four human hairs in thickness. Wood dust of this size can also be referred to as "wood flour," because it is similar in size to cereal flour.

However, NFPA 664, *Standard for the Prevention of Fires and Explosions in Wood Processing and Woodworking Facilities*, Section 3.3.24, provides an even more explicit definition for combustible wood dust:

- **3.3.24.1** Deflagrable (combustible) wood dust is a wood particulate with a median diameter of 420 microns or smaller, having a moisture content of less than 25 percent.
- **3.3.24.2** Dry non-deflagrable wood dust is a wood particulate with a median diameter greater than 420 microns or smaller, having a moisture content of less than 25 percent.

Note that moisture content does have an affect on the combustibility of wood dust. The data provided in this document is applicable if the lumber you will be sawing has a moisture content of less than 25 percent.

NFPA 664, Annex A 8.2.1 provides further specification by stating;
A.8.2.1 Assume that all wood waste in an enclosed dust collector is potentially deflagrable, unless a dust deflagration test demonstrates it is not. Wood waste usually has a dust deflagration …risk where the mean particle size is less than 420 microns and where as little as ten percent of the mixture contains dust less than 80 microns in size (half the width of a human hair). Only weak deflagrations are likely if the mean particle size exceeds 420 microns.

Identifying Combustible Risk

NFPA 664, Annex A 8.2.1, also clarifies that wood waste is commonly produced by the following:
A8.2.1 (1) Fine cutting (sanding), which produces a dust of a very fine particle size. This dust is generally assumed to be deflagrable.
A8.2.1 (2) Machining and sawing softwoods, which produces chips, shavings and course dust (Illustration 1), with only a small amount of fine dust. This process does not normally create a deflagration risk, as long as the fine dust is not allowed to separate and accumulate within confined spaces.

Illustration 1

This last section is an important clarification in the standard, and one that should be emphasized. Sawing of softwood lumber, the major source for wood dust in a component manufacturing facility, does not create significant amounts of combustible dust. However, very fine dust (smaller than 80 microns) can easily become airborne and settle on surfaces and in crevices that may be difficult to reach or to access from the production floor (exposed ceiling joists, for example).

However, NFPA 499, Section 4.3.1.1, states that the following set of conditions must be true and satisfied for ignition of a combustible material by the electrical source (a component saw, for example):
4.3.1.1(1) Combustible dust must be present;
4.3.1.1(2) The dust must be suspended in the air in proportions necessary to produce an ignitable mixture with a sufficient quantity of this suspension present in the vicinity of the electrical equipment; and
4.3.1.1(3) There must be a source of thermal or electrical energy sufficient to ignite the suspended mixture.

All of these conditions are unlikely to be present on the production floor simultaneously. Even if condition (1) is met, and combustible dust is created through your operations, it must be of a sufficient quantity and suspended in air. According to the Wood Dust Material Safety Data Sheet (MSDS), the lower explosive limit (LEL)—also called lower flammable limit (LFL)—in air is 40 g/m^3. This is the lowest concentration of a combustible wood dust in air capable of producing a flash over fire in the presence of an ignition source (arc, flame, heat). Concentrations lower than LEL are 'too lean' to burn.

To give you a sense for what wood dust LEL looks like, NFPA 499, Annex A 5.2.2, states;
A5.2.2 "from a practical point of view, a room with a concentration of dust that is above the minimum explosive concentration [Criterion 1], results in an atmosphere so dense that visibility beyond 3-5 feet is impossible."

Yet, while this is unlikely on your production floor, it is advisable to inspect your facility to ensure that there is not an enclosed area (like a dropped ceiling or crawl space) near your sawing operations that may be collecting the finer wood flour particles as they settle out of the air.

In NFPA 499, Table A. 5.2.2 (b), the concentration of wood flour necessary for combustion in a 10'X10'X10' room is listed as follows;

Table A.5.2.2(b) Dust Thickness

Material	Minimum Conc. (oz/ft^3)	Depth of Dust (in.)	Optimum Conc. (oz/ft^3)	Depth of Dust (in.)	Bulk Density (lb/ft^3)
Cornstarch	0.04	0.012	0.5	0.15	25–50
Cork	0.035	0.022	0.2	0.125	12–15
Sugar	0.045	0.0068	0.5	0.075	50–55
Wood Flour	0.035	0.016	1.0	0.47	16–36
Polyethylene (Low Density)	0.020	0.0072	0.5	0.180	21–35

Under optimal conditions, the given minimum concentration for combustion to take place is 0.035 oz/ft^3 (~36 g/m^3)—the equivalent to between 0.016 inches and 0.47 inches of dust accumulation on the entire floor surface of the room (depending on mean particle size, density and moisture content).

OSHA NEP Inspections

The standards discussed above are consistent with the instructions given to OSHA's Certified Safety & Health Officials (CSHO) in the Combustible Dust NEP. In Section E of the NEP, "Inspection & Citation Procedures,"

"A CSHO must determine that the wood dust he or she witnesses is combustible, is dispersed in air in a concentration above the LEL (40 g/m^3), and is near a combustion source, "such as an electrostatic discharge, spark, glowing ember, hot surface, friction heat, or a flame that can ignite the dispersed combustible mixture."

Further, the CSHO has to find that these conditions exist within a confined enclosure. The section states, "the combustible mixture is dispersed within a confined enclosure (and the confined enclosure does not contain sufficient deflagration venting capacity to safely release the pressures) such as a vessel, storage bin, ductwork, room or building."

Section E also presents a final criteria:

"It must be noted that a small deflagration can disturb and suspend the combustible dust, which could then serve as the fuel for a secondary (and often more damaging) deflagration or explosion."

It is likely that these criteria will be considered very closely. The CSHO will consider how likely it is that an explosion (either from wood dust or another source) in the building/area would cause the witnessed wood dust to suspend in the air in sufficient quantity as to create a secondary explosion event. According to Congressional testimony by the current CSB Interim Director, William E. Wright;

"Nearly 70 percent of the devastating explosions in manufacturing facilities between 1980 and 2005 were caused by "secondary explosions of combustible dust that was disturbed by a precipitating event."

As a consequence, it is highly probable that CSHO inspectors will be extra sensitive to large accumulations of saw dust on horizontal surfaces (floors, counters, tables, machinery, etc.). NFPA 654, *Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids,* Annex D, contains guidance on dust layer characterization and precautions as follows:

"Immediate cleaning is warranted whenever a dust layer of 1/32-inch thickness accumulates over a surface area of at least five percent of the floor area of the facility or any given room.

Illustration 2

CSHO inspectors will also look closely at how you store wood dust once you collect it from the operational areas. NFPA 664, Section 11.1.4, states:
11.1.4 Combustible waste that cannot be reintroduced to the production process or utilized for fuel shall be placed in covered metal receptacles until removed to a safe place for daily disposal.
This means it should not be placed in open bins as seen in Illustration 2.

In the Combustible Dust NEP, CSHO inspectors are told that:
"Accumulations on overhead beams, joists, ducts, the tops of equipment, and other surfaces should be included when determining the dust coverage area. The material in Annex D is an idealized approach based on certain assumptions, including uniformity of the dust layer covering the surfaces, a bulk density of 75 lb/ft^3, a dust concentration of 0.035 oz/ft^3 (~36 g/m^3), and a dust cloud height of 10 ft."

Appendix 2

In this appendix all the NFPA sections listed or discussed in this document are included in their entirety for informational purposes.

NFPA 664, Section 7.10

7.10* Machines and Processing Equipment.

7.10.1* Feed-Rate Controls (Hot Cuts). Feed rates and machine adjustments for the stock being processed on wood cutting, shaping, planing, and sanding operations shall be controlled to prevent ignition.

7.10.2 Cutter and Abrasive Maintenance.

7.10.2.1* Wood cutting, shaping, and planing equipment shall be maintained at a level of sharpness to minimize the heat generated from woodworking operations.

7.10.2.2* Abrasive cutting belts, disc surfaces, and devices shall not be used beyond their design lifetime and shall be replaced or cleaned in the manner specified by the manufacturer when showing signs of loading of the grit.

NFPA 499, Table 4.5.2

4.5 Classification of Combustible Dusts.

4.5.1 Combustible dusts are divided into three groups, depending on the nature of the dust: Group E, Group F, and Group G.

4.5.2* A listing of selected combustible dusts with their group classification and relevant physical properties is provided in Table 4.5.2. The chemicals are listed alphabetically.

4.5.3 Table 4.5.3 provides a cross-reference of selected chemicals sorted by their Chemical Abstract Service (CAS) numbers.

4.5.4 References that deal with the testing of various characteristics of combustible materials are listed in Section B.2.1, Section B.2.2, and Section B.2.4.

NFPA 664, Section 10.10

10.10 Smoking. Smoking shall be permitted only in designated areas equipped with ample devices for smoking material disposal and free of combustible/flammable hazards or storage.

NFPA 664, Section 11.1

11.1 General Requirements.

11.1.1* This chapter shall apply to the monitoring and removal of combustible waste materials in order to prevent these materials from accumulating outside, on, or around operating equipment or otherwise within the facility in sufficient quantity to create an undue fire hazard.

11.1.2* Documented housekeeping and inspection programs shall be developed and maintained.

11.1.3* Any waste material or debris found in large enough quantity that the material is heavily coated or is in any way impeding the operation of energized or moving equipment shall be collected and removed immediately.

11.1.4 Combustible waste that cannot be reintroduced to the production process or utilized as fuel shall be placed in covered metal receptacles until removed to a safe place for daily disposal.

11.1.5 Any metal collected through the cleanup process shall be separated from wood debris or combustible waste to prevent entry into the wood-handling or processing equipment, the dust-collecting system, or the scrap wood hog.

11.1.6* Production equipment shall be maintained and operated in a manner that minimizes the escape of debris or dust in accordance with Chapter 8.

11.1.7 Spaces inaccessible to housekeeping shall be sealed to prevent dust accumulation.

11.1.8* Combustible or flammable liquid spills or leaks from any source shall be cleaned up without delay.

11.1.9 Residue from condensation of oil and resin volatiles shall be removed from areas within, around, and over curing ovens, dryers, fume extraction systems, or ventilation systems.

11.1.10 Oil-soaked cloths or waste material shall be stored in approved metal receptacles with self-closing covers.

11.1.11 Oily clothing, if stored between shifts, shall be kept in metal lockers.

11.1.12 Flammable liquids shall be handled and stored in accordance with NFPA 30, *Flammable and Combustible Liquids Code.*

NFPA Standard 499, Section 3.3.3

3.3.3* Combustible Dust. Any finely divided solid material that is 420 microns or smaller in diameter (material passing a U.S. No. 40 Standard Sieve) and presents a fire or explosion hazard when dispersed and ignited in air.

NFPA 664, Section 3.3.24

3.3.24 Wood Dust.

3.3.24.1* ***Deflagrable Wood Dust.*** Wood particulate with a median diameter of 420 microns or smaller (i.e., material that will pass through a U.S. No. 40 Standard Sieve), having a moisture content of less than 25 percent (wet basis).

3.3.24.2 ***Dry Nondeflagrable Wood Dust.*** Wood particulate with a median diameter greater than 420 microns (i.e., material that will not pass through a U.S. No. 40 Standard Sieve), having a moisture content of less than 25 percent (wet basis).

NFPA 664, Annex A 8.2.1

A.8.2.1 Assume that all wood waste in an enclosed dust collector is potentially deflagrable, unless a dust deflagration test demonstrates it is not. Wood waste usually has a dust deflagration risk where the mean particle size is less than 420 microns and where as little as 10 percent of the mixture contains dust less than 80 microns in size. Only weak deflagrations are likely where the mean particle size exceeds 420 microns.

Wood waste is commonly produced by the following:

(1) Fine cutting (e.g., sanding), which produces a dust of very fine particle size. This dust is usually assumed to be deflagrable.
(2) Machining and sawing softwoods, which produces chips, shavings, and coarse dust with only a small amount of fine dust. This process does not normally create a deflagration risk, so long as the fine dust is not allowed to separate and accumulate within confined spaces.
(3) Sawing and machining hardwoods, which often produces wood waste containing considerably more dust than that from softwood. This dust is usually assumed to be deflagrable.
(4) The processing of MDF chipboard and similar boards by machining and sawing. This process can be expected to produce waste containing much fine dust. This dust is usually assumed to be deflagrable.

When mixed processing of a variety of woods occurs, the waste produced should be assumed to be deflagrable.

A.8.2.1.4 For example, dust collectors having combustible filter bags and rubber belt conveyors would pose a fire hazard, even if only green wood particulate were handled.

A.8.2.1.5 The hazard threshold used is less than 100 percent to allow for concentration increases that can occur due to system imbalances and minor changes or adjustments to material or airflow rates, and at fans, elbows, hopper feed points, and so forth. For systems that have intermittent operation and/or multiple particulate entry points, the maximum concentration should be based on the simultaneous maximum material flow rate from all entry points. For example, the dust loading for a pneumatic system that collects dust from two panel sanders should be based on the material being removed from panels passing through both sanders at the same time, even if this happens randomly.

NFPA 499, Section 4.3.1.1

4.3.1 In a Class II location, one of the following sets of conditions must be satisfied for ignition by the electrical installation.

4.3.1.1 In the first set of conditions, the following is true:

(1) A combustible dust must be present.
(2) The dust must be suspended in the air in the proportions required to produce an ignitible mixture. Further, within the context of this recommended practice, a sufficient quantity of this suspension must be present in the vicinity of the electrical equipment.
(3) There must be a source of thermal or electrical energy sufficient to ignite the suspended mixture. Within the context of this recommended practice, the energy source is understood to originate with the electrical system.

4.3.1.2* In the second set of conditions, the following is true:

(1) A combustible dust must be present.
(2) The dust must be layered thickly enough on the electrical equipment to interfere with the dissipation of heat and allow the layer to reach the ignition temperature of the dust.
(3) The external temperature of the electrical equipment must be high enough to cause the dust to reach its ignition temperature directly or to dry out the dust and cause it to self-heat.

4.3.1.3 In the third set of conditions, the following is true:

(1) A Group E dust must be present.
(2) The dust must be layered or in suspension in hazardous quantities.
(3) Current through the dust must be sufficient to cause ignition. *(See 4.4.2.)*

NFPA 499, Annex A 5.2.2,

A.5.2.2 Generally speaking, the NEC indicates that (1) if there are explosive dust clouds under normal operating conditions, or (2) if such explosive dust clouds can be produced at the same time that a source of ignition is produced, then the area is a Division 1 location. The dust described in (2) can be provided directly by some malfunction of machinery or equipment or can be provided by accumulations of dust that are thrown into the air. Presumably, if all the dust on all surfaces in a room is sufficient to produce a dust concentration above the minimum explosive concentration, then that quantity of dust should define a Division 1 location.

From a practical point of view, a room with a concentration of dust that is above the minimum explosive concentration [criterion (1)] results in an atmosphere so dense that visibility beyond 3–5 ft (0.9–1.5 m) is impossible. Such a condition is unacceptable under today's standards for chemical plant workplaces. If such a situation were encountered, accumulations on horizontal surfaces would build up very rapidly.

On the other hand, working back from dust layers on horizontal surfaces in a room to a minimum explosive concentration in the room, based on laboratory dust explosion tests, shows a very thin layer of dust on the order of ⅛ in. (3.0 mm) to be hazardous. This is an equally impractical answer, because one of the most difficult experimental problems in dust explosion test work is to obtain a reasonably uniform cloud for ignition. As a result, the test apparatus is designed specifically to obtain uniform dust distribution. For dust lying on horizontal surfaces in a room or factory to attain such an efficient uniform distribution during an upset condition obviously is impossible.

A typical calculation considers cornstarch with a powder bulk density of approximately 25 lb/ft^3 (400 kg/m^3). The minimum explosive concentration is 0.04 oz/ft^3 (40 g/m^3). In a room 10 ft (3.05 m) high × 10 ft (3.05 m) wide × 10 ft (3.05 m) long, the depth of dust that would accumulate on the floor if the room were completely filled with a cornstarch cloud at the minimum concentration can be calculated as follows:

$$\left(\frac{0.04 \text{ oz}}{\text{ft}^3}\right) \times 1000 \text{ ft}^3 \times \left(\frac{1 \text{ lb}}{16 \text{ oz}}\right) \times \left(\frac{1 \text{ ft}^3}{25 \text{ lb}}\right) = 0.1 \text{ ft}^3 \text{ dust on floor}$$

Evenly distributed over 100 ft^2, the depth of dust would be as follows:

$$\frac{0.1 \text{ ft}^3}{100 \text{ ft}^2} = 0.001 \text{ ft} = 0.012 \text{ in. } (\tfrac{1}{64} \text{ in. thick})$$

Theoretically, throwing this amount of dust from the floor and ledges into the room volume would create a hazardous condition. Accomplishing such a feat, even experimentally, would be virtually impossible.

The optimum concentration is that in which the maximum rate of pressure rise is obtained under test conditions. Because the optimum concentration is far higher than the minimum explosive concentration, the layer thicknesses necessary to produce an optimum concentration range from 0.075 to 0.5 in. (1.9 to 12.7 mm). There is then much more dust available to be thrown into uniform suspension without postulating a 100-percent efficiency of dispersal and distribution. In addition, there are a number of factors such as particle size and shape, moisture content, uniformity of distribution, and so on that negatively affect the susceptibility of a dust to ignition. Thus, dusts encountered in industrial plants tend to be less susceptible to ignition than those used in the laboratory to obtain explosion concentration data. The classifications of areas in accordance with Table A.5.2.2(a) are recommended, based on a buildup of the dust level in a 24-hour period on the major portions of the horizontal surfaces.

Table A.5.2.2(a) Division Determination Guidelines Based on Dust Layer Thickness

Thickness of Dust Layer	Classification
Greater than ⅛ in. (3.0 mm)	Division 1
Less than ⅛ in. (3.0 mm), but surface color not discernible	Division 2
Surface color discernible under the dust layer	Unclassified

Based on these thicknesses of dust, good housekeeping can determine the difference between a classification of Division 1 and a classification of Division 2, and a classification of Division 2 and unclassified. It should be emphasized, however, that housekeeping is a supplement to dust source elimination and ventilation. It is not a primary method of dust control.

Table A.5.2.2(b) shows the theoretical thickness of dust on the floor of a 10 ft (3.05 m) × 10 ft (3.05 m) × 10 ft (3.05 m) room necessary to satisfy the concentration requirements for a uniform dust cloud of minimum explosive concentration and for a uniform dust cloud of optimum concentration for four dusts.

Table A.5.2.2(b) Dust Thickness

Material	Minimum Conc. (oz/ft^3)	Depth of Dust (in.)	Optimum Conc. (oz/ft^3)	Depth of Dust (in.)	Bulk Density (lb/ft^3)
Cornstarch	0.04	0.012	0.5	0.15	25–50
Cork	0.035	0.022	0.2	0.125	12–15
Sugar	0.045	0.0068	0.5	0.075	50–55
Wood Flour	0.035	0.016	1.0	0.47	16–36
Polyethylene (Low Density)	0.020	0.0072	0.5	0.180	21–35

NFPA 654, Annex D

Annex D Dust Layer Characterization and Precautions

This annex is not a part of the requirements of this NFPA document but is included for informational purposes only.

D.1 Using a bulk density of 75 lb/ft^3 (1200 kg/m^3) and an assumed concentration of 0.35 oz/ft^3 (350 g/m^3), it has been calculated that a dust layer averaging 1/32 in. (0.8 mm) thick and covering the floor of a building is sufficient to produce a uniform dust cloud of optimum concentration, 10 ft (3 m) high, throughout the building. This situation is idealized; several factors should be considered.

First, the layer will rarely be uniform or cover all surfaces, and second, the layer of dust will probably not be dispersed completely by the turbulence of the pressure wave from the initial explosion. However, if only 50 percent of the 1/32 in. (0.8 mm) thick layer is suspended, this material is still sufficient to create an atmosphere within the explosible range of most dusts.

Consideration should be given to the proportion of building volume that could be filled with a combustible dust concentration. The percentage of floor area covered can be used as a measure of the hazard. For example, a 10 ft × 10 ft (3 m × 3 m) room with a 1/32 in. (0.8 mm) layer of dust on the floor is obviously hazardous and should be cleaned. The same 100 ft^2 (9.3 m^2) area in a 2025 ft^2 (188 m^2) building is a moderate hazard. The hazardous area represents about 5 percent of a floor area and is about as much coverage as should be allowed in any plant. To gain proper perspective, the overhead beams and ledges should also be considered. Rough calculations show that the available surface area of the bar joist is about 5 percent of the floor area. For steel beams, the equivalent surface area can be as high as 10 percent.

D.2 From the information in Section D.1, the following guidelines can be used to establish a cleaning frequency:

(1) Dust layers 1/32 in. (0.8 mm) thick can be sufficient to warrant immediate cleaning of the area [1/32 in. (0.8 mm) is about the diameter of a paper clip wire or the thickness of the lead in a mechanical pencil].
(2) The dust layer is capable of creating a hazardous condition if it exceeds 5 percent of the building floor area.
(3) Dust accumulation on overhead beams and joists contributes significantly to the secondary dust cloud and is approximately equivalent to 5 percent of the floor area. Other surfaces, such as the tops of ducts and large equipment, can also contribute significantly to the dust cloud potential.
(4) The 5 percent factor should not be used if the floor area exceeds 20,000 ft^2 (1860 m^2). In such cases, a 1000 ft^2 (93 m^2) layer of dust is the upper limit.
(5) Due consideration should be given to dust that adheres to walls, since it is easily dislodged.
(6) Attention and consideration should also be given to other projections such as light fixtures, which can provide surfaces for dust accumulation.
(7) Dust collection equipment should be monitored to ensure it is operating effectively. For example, dust collectors using bags operate most effectively between limited pressure drops of 3 in. to 5 in. of water (0.74 kPa to 1.24 kPa). An excessive decrease or low drop in pressure indicates insufficient coating to trap dust.

NFPA 664, Section 11.1.4

11.1 General Requirements.

11.1.1* This chapter shall apply to the monitoring and removal of combustible waste materials in order to prevent these materials from accumulating outside, on, or around operating equipment or otherwise within the facility in sufficient quantity to create an undue fire hazard.

11.1.2* Documented housekeeping and inspection programs shall be developed and maintained.

11.1.3* Any waste material or debris found in large enough quantity that the material is heavily coated or is in any way impeding the operation of energized or moving equipment shall be collected and removed immediately.

11.1.4 Combustible waste that cannot be reintroduced to the production process or utilized as fuel shall be placed in covered metal receptacles until removed to a safe place for daily disposal.

11.1.5 Any metal collected through the cleanup process shall be separated from wood debris or combustible waste to prevent entry into the wood-handling or processing equipment, the dust-collecting system, or the scrap wood hog.

11.1.6* Production equipment shall be maintained and operated in a manner that minimizes the escape of debris or dust in accordance with Chapter 8.

11.1.7 Spaces inaccessible to housekeeping shall be sealed to prevent dust accumulation.

11.1.8* Combustible or flammable liquid spills or leaks from any source shall be cleaned up without delay.

11.1.9 Residue from condensation of oil and resin volatiles shall be removed from areas within, around, and over curing ovens, dryers, fume extraction systems, or ventilation systems.

11.1.10 Oil-soaked cloths or waste material shall be stored in approved metal receptacles with self-closing covers.

11.1.11 Oily clothing, if stored between shifts, shall be kept in metal lockers.

11.1.12 Flammable liquids shall be handled and stored in accordance with NFPA 30, *Flammable and Combustible Liquids Code*.

Section E of the OSHA National Emphasis Program, "Inspection & Citation Procedures"

E. Inspection and Citation Procedures.
1. CSHOs should recognize that the following criteria must be met before a deflagration can occur:
a. The dust has to be combustible.
b. The dust has to be dispersed in air or another oxidant, and the concentration of this dispersed dust is at or above the minimum explosible concentration (MEC).
c. There is an ignition source, such as an electrostatic discharge, spark, glowing ember, hot surface, friction heat, or a flame that can ignite the dispersed combustible mixture that is at or above the MEC.

2. CSHOs should recognize that the following criteria must be met before an explosion can occur:
a. The above criteria for deflagration must be present.
b. The combustible mixture is dispersed within a confined enclosure (and the confined enclosure does not contain sufficient deflagration venting capacity to safely release the pressures) such as a vessel, storage bin, ductwork, room or building. It must be noted that a small deflagration can disturb and suspend the combustible dust, which could then serve as the fuel for a secondary (and often more damaging) deflagration or explosion.

3. CSHOs should be able to recognize the following conditions that may indicate that a potential dust deflagration, other fire, or explosion hazard exists:
a. Plant History of Fires: The plant has a history of fires involving combustible dusts.
b. Material Safety Data Sheets (MSDS): The MSDS may indicate that a particular dust is combustible and can cause explosions, deflagrations, or other fires. However, do not use MSDSs as a sole source of information because this information is often excluded from MSDSs.
c**.** Dust Accumulations: Annex D of NFPA 654 contains guidance on dust layer characterization and precautions. It indicates that immediate cleaning is warranted whenever a dust layer of 1/32-12 inch thickness accumulates over a surface area of at least 5% of the floor area of the facility or any given room. The 5% factor should not be used if the floor area exceeds 20,000 ft2, in which case a 1,000 ft2 layer of dust is the upper limit. Accumulations on overhead beams, joists, ducts, the tops of equipment, and other surfaces should be included when determining the dust coverage area. Even vertical surfaces should be included if the dust is adhering to them. Rough calculations show that the available surface area of bar joists is approximately 5 % of the floor area and the equivalent surface area for steel beams can be as high as 10%. The material in Annex D is an idealized approach based on certain assumptions, including uniformity of the dust layer covering the surfaces, a bulk density of 75 lb/ ft3, a dust concentration of 0.35 oz/ ft 3, and a dust cloud height of 10 ft. Additionally, FM Data Sheet 7-76 contains a formula to determine the dust thickness that may create an explosion hazard in a room, when some of these variables differ.
d. CSHOs should observe areas of the plant for dust accumulations of greater than 1/32 of an inch (approximately equal to the thickness of a typical paper clip). Likely areas of dust accumulations within a plant are:
♦ structural members
♦ conduit and pipe racks
♦ cable trays
♦ floors
♦ above ceiling
on and around equipment (leaks around dust collectors and ductwork.)
e. If CSHOs find that there are potential combustible dust hazards, dust samples must be safely collected. CSHOs shall use means of access to upper levels of a facility only when this can be done safely. Dust samples shall be submitted to OSHA's Salt Lake Technical Center (SLTC) for analysis. Locations from which to collect separate samples:
♦ "High spaces" such as roof beams, open web beams, tops of pipes and ductwork, and other horizontal surfaces located as high in the overhead as possible. Note: These are the preferred locations; however, if a means of safe access is not available, sample(s) should not be collected.
♦ Equipment and floors where dust has accumulated.
♦ The interior (i.e., bins and/or bags) of a dust collector.
♦ Within ductwork.