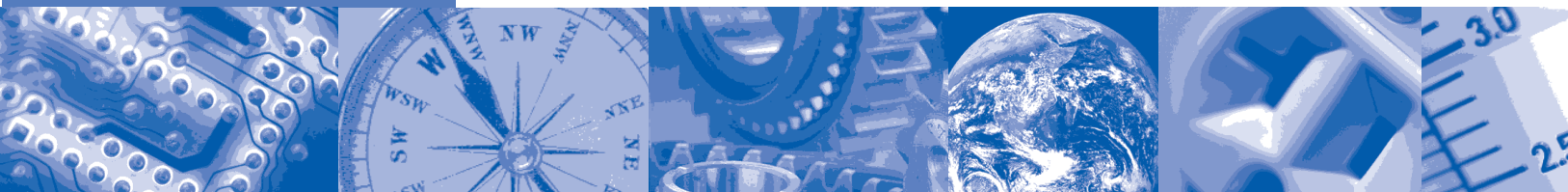


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Area Classification in Hazardous (Classified) Dust Locations



**ISA—The Instrumentation,
Systems, and
Automation Society**

Approved 29 January 1988



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ISA-12.10-1988
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1 Purpose

This standard recommends procedures for classifying locations made hazardous by the presence of a cloud or blanket of combustible dust. It conforms with the U.S. *National Electrical Code*® (*NEC*®)* and the *Canadian Electrical Code (CEC)*, and is intended to expand and clarify both.

2 Scope

This standard refers only to combustible mixtures created by dusts — such as agricultural, carbonaceous, plastic, chemical, and metal dusts. Such materials are classified in *NEC*® Article 500 as Class II, Groups E, F, and G.

This standard classifies a location based on its dust cloud concentration, its accumulated combustible dust layer thickness, and its dust bulk resistivity; it also contains references to, and data on, the explosivity of common dusts, as well as references to laboratory equipment and test procedures for evaluating the explosivity of dusts.

This standard is intended for use by persons trained in the design and installation of instrument systems and by inspection authorities in the approval of such installations.

NOTE: This standard is not intended to address hazards created by the emission of Class I combustible gases from combustible dusts, e.g., the emission of methane from freshly crushed coal.

3 Definitions

Combustible dusts: Dusts which (when mixed with air in certain proportions) can be ignited and will propagate flame.

Combustible dust layer: Any surface accumulation of combustible dust that is large enough to propagate flame or will degrade and ignite.

Dust: Any finely divided solid material 420µm or smaller in diameter (material passing a U.S. No. 40 Standard Sieve).

NOTE: *Larger-sized particles can also cause explosions — see References 4 and 15.*

Minimum cloud ignition temperature: The minimum temperature at which a combustible dust atmosphere will autoignite and propagate an explosion.

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Minimum dust layer ignition temperature: The minimum temperature of a surface that will ignite dust lying on it after a long time (theoretically, until infinity) (see Reference 4). In most dusts, free moisture has been vaporized before ignition.

Minimum explosion concentration: The minimum concentration of a dust cloud that, when ignited, will propagate flame away from the source of ignition.

NOTE 1: The measurable combustible properties of dusts depend not only on the chemical structure of the dust, but on test conditions, dust particle size, weight, density, and other particle characteristics.

NOTE 2: See Appendix A.1 for NEC® definitions.

4 Dust explosion parameters and variables

4.1 The nature of a dust explosion. A dust explosion is the rapid burning of a cloud of dispersed dust accompanied by the release of thermal energy in a pressure wave. The flame can travel rapidly through the dust cloud, igniting other adjacent combustibles.

An initial explosion often dislodges settled dust from building structures and machinery. This dislodged settled dust may be ignited by glowing residue from the initial explosion, and a secondary explosion may follow. The quantity of dust thus redispersed may cause more extensive injury and property damage than the initial dust cloud. Good housekeeping in an area made hazardous (classified) by dust is vitally important, and will keep accumulations on structures and machinery to a minimum.

Even a puff of air in the presence of an ignition source or a small flame can initiate a dust explosion. While dust accumulated as a layer will not explode ordinarily, it may melt, char, or burn. This burning can generate heat and air turbulence that may disperse further amounts of dust, which may then explode.

4.2 Dust dispersion mechanics and control. Dust often disperses horizontally from its source. The extent of dispersion depends on the initial horizontal air velocity, the release height, and the particle settling time. For spherical particles the settling time can be estimated from Stokes's Law, as given in Equation 1:

$$V_s = \frac{h}{t} = \frac{g\rho D^2 10^{-8}}{18\mu} \quad (\text{Eq. 1})$$

where

V_s = still air settling velocity, in centimeters per second

h = release height, in centimeters

t = settling time, in seconds

g = gravitational constant, 980 cm/s²

ρ = particle density, in grams per cubic centimeter (1.44 g/cm³ for dry flour)

D = particle size (diameter), in micrometers

μ = air viscosity, in poises (180 X 10⁻⁶ P [X 10¹ = Pa·s] at normal temperature and pressure)

Equation 1 is applicable for particles from 1 to 100 μm in diameter (in free fall), with approximately a 10-percent error at low concentrations. The larger particles will fall nearby; the smaller particles will fall some distance from the release point.

Well-designed process equipment and buildings have surfaces which are smooth and easily cleaned, and lack ledges or inaccessible pockets where dust could accumulate. Process dust should be mechanically sealed in process piping, vessels, and ducts when practical. Where dusty materials must be handled in the open, dust should be collected. Frequent cleanup of settled dust will substantially reduce the likelihood of combustible dust accumulations in a location and substantially reduce the likelihood of a *major secondary dust explosion*.

4.3 Dust cloud ignition. The factors usually considered in dust cloud ignition are the following:

- 1) Minimum explosion concentration
- 2) Minimum cloud ignition temperature
- 3) Minimum ignition energy
- 4) Maximum explosion pressure
- 5) Maximum rate of explosion pressure rise
- 6) Minimum oxygen concentration

These terms are defined and discussed in References 3,4, 6–9, 11, and 12.

The preceding factors are influenced by

- 1) Composition
- 2) Particle size
- 3) Moisture content
- 4) Particle shape
- 5) Particle surface area
- 6) Oxygen concentration

Table 1 compares the relative ignition properties of Class I and Class II materials. Laboratory explosion pressures are approximately the same for both classes, but detonation and pressure piling can cause that pressure to increase significantly. Whether this will happen or not depends on the shape of the enclosure. The lower explosive limit (LEL) is a measure of Class I explosive concentration. The values of explosion pressure, time to peak pressure, and explosion pressure rate of rise depend on the volume and geometry of the test apparatus. The minimum explosion concentration is a similar measure for Class II materials. Unlike Class I materials, the surface ignition temperature for Class II materials (dusts) must be expressed both for layer and cloud form. The two usually are not equal.

4.4 Dust layer ignition. The two factors to be considered in combustible dust layer ignition are the layer ignition temperature and the combustible dust layer thickness.

The layer ignition temperature of most materials is lower than their cloud ignition temperature. (A few comparisons are made in **Table 1**.) A prolonged elevated temperature will decrease the minimum layer ignition temperature. For cornstarch, the layer ignition temperature changes from 500°C for 0.3 hours (h) to 150°C for 70 h.

The combustible dust layer thickness is the minimum thickness that will allow a fire or glow to propagate in a settled dust. A method for determining the minimum combustible dust layer thickness is given in Appendix A.5.

5 Procedures for the classification of various areas of existing plants

(Measurement procedures and examples are given in Appendix A.)

5.1 Division 1 Locations. Locations should be classified as Division 1 if any of the following conditions exist:

- 1) The dust cloud exists under normal conditions at concentrations above the minimum explosion concentration.

NOTE: Combustible dust clouds may be seen. An explosive dust cloud concentration (see A.3) must usually reach the point where visibility is limited to a few feet. Division 1 locations usually exist inside and around process equipment, e.g., at filling and dispensing points, and inside and around leak points where accumulations of dust exist.

- 2) "Large" dust accumulations (refer to Appendix A.5 and Figure 1) may exist for extended periods of time (usually due to inadequate housekeeping or dust removal systems).

NOTE: Good housekeeping and/or the installation of dust collection systems can substantially reduce the accumulation of dust.

Table 1 — Comparison of relative ignition properties of Class I and Class II materials

Ignition Property	Class I: Gases & Vapors				Class II: Dust Clouds			
	Methane	Propane	Hydrogen	Acetylene	Wheat Starch	Rice	Safflower Meal	Sugar
Minimum ignition energy, mJ	0.30	0.25	0.019	0.017	20	40	20	30
Maximum explosion pressure, kg/cm ² (1 kg/cm ² = 1 kPa)	7.17	8.58	7.39	10.3	7.38	6.54	5.90	6.40
Time to peak pressure, s	70	46	7	14	—	—	—	—
Explosion pressure rate of rise, kg/cm ² /s	—	—	—	—	597.6	253.1	203.9	351.5
Lower explosive limit, % volume	5.0	2.1	4.0	2.5	—	—	—	—
Minimum explosion concentration, mg/L	—	—	—	—	25	45	55	35
Autoignition temperature, °C	435	198	470	272	—	—	—	—
Layer surface ignition temperature, °C	—	—	—	—	—	220	210	400
Cloud/surface ignition temperature, °C	—	—	—	—	420	440	460	370

*Recent work indicates that minimum ignition energies are considerably lower than these values when long spark discharge times are used. See Reference 5.

NOTE: The values indicated above are based on the techniques described in References 3,4, 6–9, 11, and 12.

- 3) Conditions exist which could meet Division 2 requirements, but the dust is conductive.

NOTE: *An electrically conductive dust will produce heating and possibly ignition of the dust if allowed to bridge energized electrical terminals. Therefore, a Division 1 classification is required.*

- 4) Where mechanical failure or abnormal operation might simultaneously result in ignitable mixtures and an ignition source through failure of electrical equipment.

5.2 Division 2 locations. Locations should be classified as Division 2 if any of the following conditions exist:

- 1) The frequency of occurrence of a combustible dust cloud is very low.
- 2) Dust accumulations (see Appendix A.5.1 and Figure 1) exceed the combustible dust layer thickness but are not sufficient to justify a Division 1 classification.

NOTE: An effective housekeeping program and a properly designed and installed dust removal system can substantially reduce dust accumulation.

- 3) The location is adjacent to a Division 1 location, unless the dust is conductive (see Section 5.1).

NOTE: Where conductive dusts are involved, there is only a Division 1 classification.

- 4) Dust is processed in an enclosed system but an occasional leak occurs at flexible connections, rotary feeders, or other such sources,

NOTE: The Division 2 classification extends wherever the dust layer thickness exceeds the combustible dust layer thickness.

- 5) Locations where combustible dust is processed in an enclosed system where release through venting relief panels, seal failures, or accidental rupture may result in abrupt release of combustible concentrations.

5.3 Unclassified locations. Locations should be noted as "unclassified" under the following conditions:

- 1) Where the dust cloud concentration does not exceed the minimum explosion concentration; and
- 2) Where the combustible dust layer exists infrequently.

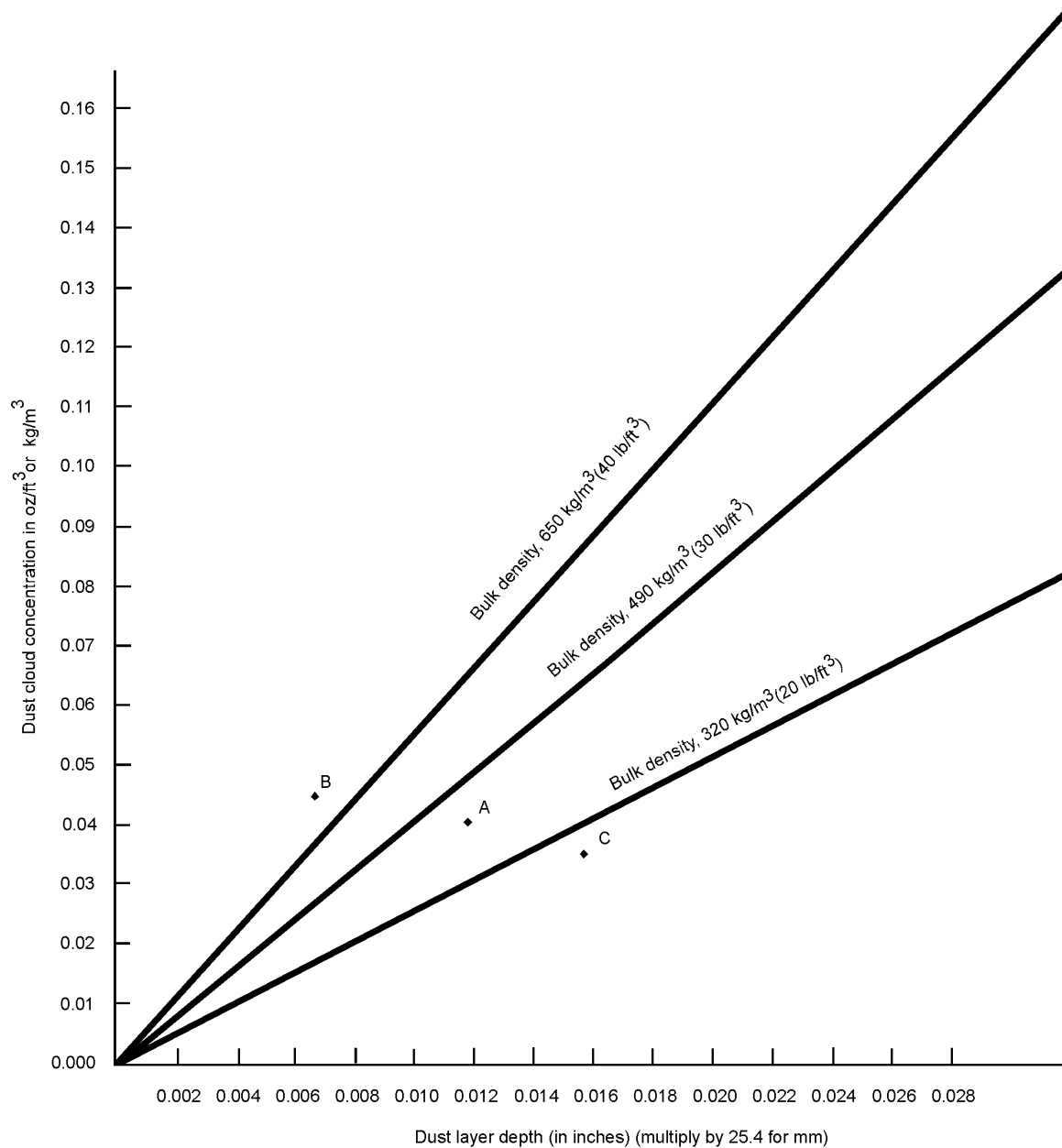
Examples are:

- a) Where excellent housekeeping is provided to areas adjacent to a Division 2 location.
- b) Where the dust layer has diminished to less than the combustible dust layer thickness.

The means of defining the extent of the areas to be classified as "nonhazardous" (unclassified) are

- 1) Measurement — refer to the appendixes.
- 2) Appraisal — use judgment based on experience with the measurement of dusty areas.

Probability definitions of Divisions 1 and 2 have been mentioned in international standards and are discussed in [Reference 2](#); they are included in [Appendix A](#) as reference material.



A is cornstarch — minimum explosive concentration is 0.04 kg/m³ (0.04 oz/ft³) (minimum depth of dust to produce this density is 0.012).

B is sugar — minimum explosive concentration is 0.045 kg/m³ (0.045 oz/ft³) (minimum depth of dust to produce this density is 0.0068).

C is wood flour — minimum explosive concentration is 0.035 kg/m³ (0.035 oz/ft³) (minimum depth of dust to produce this density is 0.016).

**Figure 1 — Dust cloud concentration vs. dust layer depth for height of 3 m (10 ft)
— assuming uniform dust distribution**