

NFPA[®] 499

Recommended Practice for the Classification of Combustible Dusts and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas

2024 Edition



NFPA, 1 Batterymarch Park, Quincy, MA 02169-7471
An International Codes and Standards Organization

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NFPA® 499

Recommended Practice for the

Classification of Combustible Dusts and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas

2024 Edition

This edition of NFPA 499, *Recommended Practice for the Classification of Combustible Dusts and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas*, was prepared by the Technical Committee on Electrical Equipment in Chemical Atmospheres. It was issued by the Standards Council on April 23, 2023, with an effective date of May 13, 2023, and supersedes all previous editions.

This edition of NFPA 499 was approved as an American National Standard on May 13, 2023.

Origin and Development of NFPA 499

The Technical Committee on Electrical Equipment in Chemical Atmospheres began the development of NFPA 497B, *Recommended Practice for the Classification of Class II Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas*, in 1989. The technical committee based the diagrams in this document on various NFPA codes and standards and on accepted practices in the chemical process industries. The first edition of this recommended practice was adopted by the NFPA membership at the 1990 November Technical Meeting, which became the 1991 edition.

In 1993, the technical committee combined the information on group classifications of dusts located in NFPA 497M, *Classification of Gases, Vapors, and Dusts for Electrical Equipment in Hazardous (Classified) Locations*, and the information in NFPA 497B into an expanded version and renamed the document *Recommended Practice for the Classification of Combustible Dusts and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas*, 1997. The table information on dusts was expanded to include CAS numbers for clarity and user friendliness.

In 2001, the technical committee entered NFPA 499 into the November 2003 revision cycle. The 2004 edition was significantly revised and reorganized to comply with the 2003 NFPA *Manual of Style* for technical committee documents. The organizational and editorial changes enhanced the usability of this recommended practice. In addition, editorial changes were made to harmonize the text with the requirements of NFPA 70®, *National Electrical Code*®.

The 2008 edition of NFPA 499 was the culmination of a revision cycle that began with the document being entered into cycle in January 2006. NFPA 499 is closely tied to the electrical installation requirements for hazardous (classified) locations in NFPA 70. To ensure correlation with revisions to the 2008 edition of NFPA 70, the Technical Committee on Electrical Equipment in Chemical Atmospheres was granted permission by the NFPA Standards Council to enter into a 3-year (Fall 2007) revision cycle. Significant revisions to the 2008 edition included the following:

- (1) Changes to the scope to specify that explosives, pyrotechnics, and blasting agents have unique hazards not addressed by the document
- (2) Revisions to Table 4.5.2 on composition and ignition temperature of combustible materials to correlate with information contained in other industry documents

The 2013 edition was a complete revision to update references and extracted text. As a result of updating ASTM references, the 2010 edition of ASTM E1226, *Standard Test Method for Explosibility of Dust Clouds*, was incorporated, which eliminated the use of the ignition sensitivity (IS) and explosion severity (ES) criteria in NFPA 499. Those criteria were eliminated because ASTM E1226 now has a “Go/No-Go” criterion that assesses the combustibility of a dust. Also, a new Chapter 4, on general criteria for combustible dusts and their ignition characteristics, was added.

The 2017 edition was revised to update consistency between the figures and text regarding a transitional classified location around doorways. Other revisions were made to correlate with

revisions to the 2017 edition of *NFPA 70*. There were also extensive revisions to add the zone classification system from *NFPA 70*.

The 2021 edition was revised to update the definition of *combustible flyings* to *combustible fibers/flyings*, and add the definition for *ignitable fibers/flyings*. The classification of combustible fibers/flyings was clarified. Those changes correlated this recommended practice with dust and electrical standards and ensured that material posing a flash-fire or explosion hazard was evaluated as hazardous (classified) locations, regardless of particle size. Classification of portable electronic products (PEPs) was included to correlate with UL 121203, *Portable Electronic Products Suitable for Use in Class I and II, Division 2, Class I, Zone 2 and Class III, Division 1 and 2 Hazardous (Classified) Locations*. In addition, area electrical classifications were revised throughout the document to correlate with the *NEC*® electrical classification.

For the 2024 edition, Section 4.2 has been revised to include a dust combustibility screening step to assess whether a dust poses a fire or flash-fire hazard if it is not considered combustible based on ASTM E1226 testing. Revisions have been made to allow the zone system to be used for layer ignition hazards. The definition for *hazardous (classified) locations* also has been added from the *NEC*®.

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Committee Scope: This Committee shall have primary responsibility for documents on (1) developing data on the properties of chemicals enabling proper selection of electrical equipment for use in atmospheres containing flammable gases, vapors or dusts; (2) making recommendations for the prevention of fires and explosions through the use of continuously purged, pressurized, explosion-proof, or dust-ignition-proof electrical equipment where installed in such chemical atmospheres.

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NFPA 499

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NOTICE: An asterisk (*) following the number or letter designating a paragraph indicates that explanatory material on the paragraph can be found in Annex A.

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Information on referenced and extracted publications can be found in Chapter 2 and Annex B.

Chapter 1 Administration

1.1 Scope.

1.1.1* This recommended practice provides information on the classification of combustible dusts and of hazardous (classified) locations for electrical installations in chemical process areas and other areas where combustible dusts are produced or handled.

1.1.2 This recommended practice provides information on combustible dusts as it relates to the proper selection of electrical equipment in hazardous (classified) locations in accordance with NFPA 70®.

1.1.3 The tables of selected combustible dusts contained in this document are not intended to be all-inclusive.

1.2 Purpose.

1.2.1 The purpose of this recommended practice is to provide the user with a basic understanding of the parameters that determine the degree and the extent of the hazardous (classified) location. This recommended practice also provides the user with examples of the applications of these parameters.

1.2.2 This recommended practice is intended as a guide and should be applied with sound engineering judgment. Where all factors are properly evaluated, a consistent area classification scheme can be developed.

1.2.3 This recommended practice is based on the criteria established by Articles 500 and 502 of NFPA 70.

1.2.4 The application of this recommended practice does not address all potential hazards associated with solid particulate materials, including, but not limited to, the possible need for explosion venting or explosion suppression addressed in other NFPA standards.

1.2.5* This recommended practice provides guidance for classification of combustible fibers/flyings and of hazardous (classified) locations where these present a flash-fire hazard or explosion hazard when dispersed and ignited in air.

1.2.6 This recommended practice provides guidance for classification of ignitable fibers/flyings and of hazardous (classified) locations where these present a hazard of layer ignition due to accumulation.

1.3 Application.

1.3.1 This recommended practice applies to those locations where combustible dusts are produced, processed, or handled and where combustible dust released into the atmosphere or accumulated on surfaces could be ignited by electrical equipment.

1.3.2 This recommended practice applies to chemical process areas, which as used in this document, could be defined as any of the following:

- (1) A chemical process plant
- (2) A part of a chemical process plant
- (3) A part of a manufacturing facility where combustible dusts are produced or used in chemical reactions or are handled or used in operations such as mixing, coating, extrusion, conveying, drying, and/or grinding

1.3.3 This recommended practice does not apply to situations that could involve catastrophic failure of, or catastrophic discharge from, silos, process vessels, pipelines, tanks, hoppers, or conveying or elevating systems.

1.3.4 This recommended practice does not apply to the unique hazards associated with explosives, pyrotechnics, blasting agents, pyrophoric materials, or oxygen-enriched atmospheres that might be present.

1.4 Relationship to NFPA Codes and Standards. This recommended practice is not intended to supersede or conflict with NFPA 36, NFPA 61, NFPA 68, NFPA 69, NFPA 70, NFPA 484, NFPA 654, NFPA 655, and NFPA 664.

Chapter 2 Referenced Publications

2.1 General. The documents or portions thereof listed in this chapter are referenced within this recommended practice and should be considered part of the recommendations of this document.

2.2 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.

NFPA 36, *Standard for Solvent Extraction Plants*, 2021 edition.

NFPA 61, *Standard for the Prevention of Fires and Dust Explosions in Agricultural and Food Processing Facilities*, 2020 edition.

NFPA 68, *Standard on Explosion Protection by Deflagration Venting*, 2023 edition.

NFPA 69, *Standard on Explosion Prevention Systems*, 2019 edition.

NFPA 70®, *National Electrical Code*®, 2023 edition.

NFPA 484, *Standard for Combustible Metals*, 2022 edition.

NFPA 654, *Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids*, 2020 edition.

NFPA 655, *Standard for Prevention of Sulfur Fires and Explosions*, 2017 edition.

NFPA 664, *Standard for the Prevention of Fires and Explosions in Wood Processing and Woodworking Facilities*, 2020 edition.

2.3 Other Publications.

2.3.1 ASTM Publications. ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959.

ASTM D3175, *Standard Test Method for Volatile Matter in the Analysis Sample of Coal and Coke*, 2020.

ASTM E11, *Standard Specification for Woven Wire Test Sieve Cloth and Test Sieves*, 2020.

ASTM E1226, *Standard Test Method for Explosibility of Dust Clouds*, 2019.

ASTM E1491, *Standard Test Method for Minimum Autoignition Temperatures of Dust Clouds*, 2006 (2019).

ASTM E2021, *Standard Test Method for Hot-Surface Ignition Temperature of Dust Layers*, 2009 (2015).

Δ 2.3.2 UL Publications. Underwriters Laboratories Inc., 333 Pfingsten Road, Northbrook, IL 60062-2096.

UL 121203, *Recommended Practice for Portable/Personal Electronic Products Suitable for Use in Class I, Division 2, Class I, Zone 2, Class II, Division 2, Class III, Division 1, Class III, Division 2, Zone 21 and Zone 22 Hazardous (Classified) Locations*, 2021.

2.3.3 Other Publications.

UN Recommendations on the Transport of Dangerous Goods: Model Regulations - Manual of Tests and Criteria, 2019.

Merriam-Webster's Collegiate Dictionary, 11th edition, Merriam-Webster, Inc., Springfield, MA, 2020.

2.4 References for Extracts in Recommendations Sections.

NFPA 68, *Standard on Explosion Protection by Deflagration Venting*, 2018 edition.

NFPA 70®, *National Electrical Code*®, 2023 edition.

Chapter 3 Definitions

3.1 General. The definitions contained in this chapter apply to the terms used in this recommended practice. Where terms are not defined in this chapter or within another chapter, they should be defined using their ordinarily accepted meanings within the context in which they are used. *Merriam-Webster's Collegiate Dictionary*, 11th edition, is the source for the ordinarily accepted meaning.

3.2 NFPA Official Definitions.

3.2.1 Recommended Practice. An NFPA standard similar in content and structure to a code or standard but that contains only nonmandatory provisions using the word "should" to indicate recommendations in the body of the text.

3.2.2 Should. Indicates a recommendation or that which is advised but not required.

3.3 General Definitions.

3.3.1* Autoignition Temperature (AIT). The minimum temperature required to initiate or cause self-sustained combustion of a solid, liquid, or gas independently of the heating or heated element.

3.3.2 CAS. Chemical Abstract Service.

3.3.3* Combustible Dust. Solid particles that are 500 µm or smaller (i.e., material passing a US No. 35 Standard Sieve as defined in ASTM E11-17, *Standard Specification for Woven Wire Test Sieve Cloth and Test Sieves*) that can form an explosible mixture when suspended in air at standard atmospheric pressure and temperature.

3.3.4 Fibers/Flyings.

3.3.4.1* Combustible Fibers/Flyings. Fibers/flyings, where any dimension is greater than 500 µm in nominal size, which can form an explosible mixture when suspended in air at standard atmospheric pressure and temperature.

3.3.4.2* Ignitable Fibers/Flyings. Fibers/flyings where any dimension is greater than 500 µm in nominal size, which are not likely to be in suspension in quantities to produce an explosible mixture, but could produce an ignitable layer fire hazard.

3.3.5* Hybrid Mixture. An explosible heterogeneous mixture, comprising gas with suspended solid or liquid particulates, in which the total flammable gas concentration is ≥10 percent of the lower flammable limit (LFL) and the total suspended particulate concentration is ≥10 percent of the minimum explosible concentration (MEC). [68, 2018]

3.3.6 Ignitable Mixture. A generic term used to describe either a mixture of dust in air or a hybrid mixture that can burn, flame, or explode and that is within its flammable range.

N 3.3.7 Locations.

N 3.3.7.1 Hazardous (Classified) Locations. Locations where fire or explosion hazards might exist due to flammable gases, flammable liquid-produced vapors, combustible liquid-produced vapors, combustible dusts, combustible fiber/flyings, or ignitable fibers/flyings. [70, 2023]

3.3.7.2 Unclassified Locations. Locations determined to be neither Class I, Division 1; Class I, Division 2; Zone 0; Zone 1; Zone 2; Class II, Division 1; Class II, Division 2; Class III,

Division 1; Class III, Division 2; Zone 20; Zone 21; Zone 22; nor any combination thereof. [70, 2023]

3.3.8 Material Form. The particle size and composition within the process at a defined place.

3.3.9 Material Groups.

3.3.9.1 Combustible Dust Division Material Groups. The division area classification, addressed in Articles 500 and 502 of *NFPA 70*, divides combustible dusts into Group E, Group F, and Group G.

3.3.9.1.1* Group E. Atmospheres containing combustible metal dusts, including 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.

3.3.9.1.2* Group F. Atmospheres containing combustible carbonaceous dusts that have more than 8 percent total entrapped volatiles (see *ASTM D3175, Standard Test Method for Volatile Matter in the Analysis Sample of Coal and Coke, for coal and coke dusts*) or that have been sensitized by other materials so that they present an explosion hazard.

3.3.9.1.3* Group G. Atmospheres containing combustible dusts not included in Group E or Group F, including flour, grain, wood, plastic, and chemicals.

3.3.9.2 Zone Material Groups. The zone area classification, addressed in Article 506 of *NFPA 70*, divides combustible materials into Group IIIA, Group IIIB, and Group IIIC.

3.3.9.2.1 Group IIIC. Combustible metal dust, including combustible metal fibers/flyings.

3.3.9.2.2 Group IIIB. Combustible dust other than combustible metal dust.

3.3.9.2.3* Group IIIA. Combustible fibers/flyings or ignitable fibers/flyings other than metal.

Chapter 4 Combustible Dusts

4.1 General.

4.1.1 Criteria for Combustible Dust Ignition. The pertinent criteria for ignition of any combustible dust cloud or layer include the following:

- (1) Air
- (2) The material form either dispersed in air (oxidant) at or exceeding the minimum explosible concentration (MEC) for an explosion or in a layer at or exceeding the layer ignition temperature
- (3) Ignition source such as an electrostatic discharge, an electric current arc or spark, a glowing ember, a hot surface, welding slag, frictional heat, or a flame

4.1.2 Material Form.

4.1.2.1 Dust discharged or leaking from equipment into the atmosphere will exist in the air as a cloud and over time will settle due to gravity, resulting in an accumulated dust layer. In some cases, both a cloud and a layer could exist simultaneously.

4.1.2.2 The size and density of the dust particles, the internal pressure propelling the dust out of the equipment, the size of the leak opening, the elapsed time of emission, the height of

the emission, and air currents in the vicinity all contribute to the cloud and layer presence.

4.1.2.3 Dust in process vessels, in air-material separators, or in transport systems can exist as a cloud and could settle, resulting in an accumulated dust layer. In some cases, both a cloud and a layer could exist simultaneously.

4.1.3 Combustible Dust Clouds.

4.1.3.1 Combustible dust clouds have the potential to cause significant overpressures or explosions when ignited. Some dusts have particles that are extremely fine and light (i.e., have a low specific particle density). Such particles could behave similar to vapors and could remain in suspension for long periods. These particles could travel far from the emitting source and could collect as layers on surfaces above the source.

4.1.3.2* Generally, as particle size increases, the ability of the combustible dust to remain in a cloud decreases, but the creation of combustible dust layers increases.

4.1.3.3 A combustible dust cloud can be ignited on contact with a hot surface. Typically, the cloud ignition temperature is higher than the layer ignition temperature; however, if a material melts when in a layer, the opposite is often true.

4.1.3.4* The application of hazardous area classification, while reducing the risk of ignition from electrical sources, does not address the potential overpressure effects from a combustible dust explosion or hazards from a flash fire. Other NFPA standards address such hazards.

4.1.4 Combustible Dust Layers.

4.1.4.1 Not only do combustible dust layers have the potential to be ignited, but depending on the speed of the burning, the dust could also be dispersed into the air as a cloud. If the dust is ignited, a dust flash fire could result. Airflow induced by such an event will disperse more dust from the layer into the air, resulting in a larger explosion. Often, the secondary explosion does more damage.

4.1.4.2 Combustible dust layers can cause electrical equipment to overheat because they tend to act as insulation. The overheated electrical equipment can result in an ignition of the dust layer, which could then result in ignition of a dust cloud.

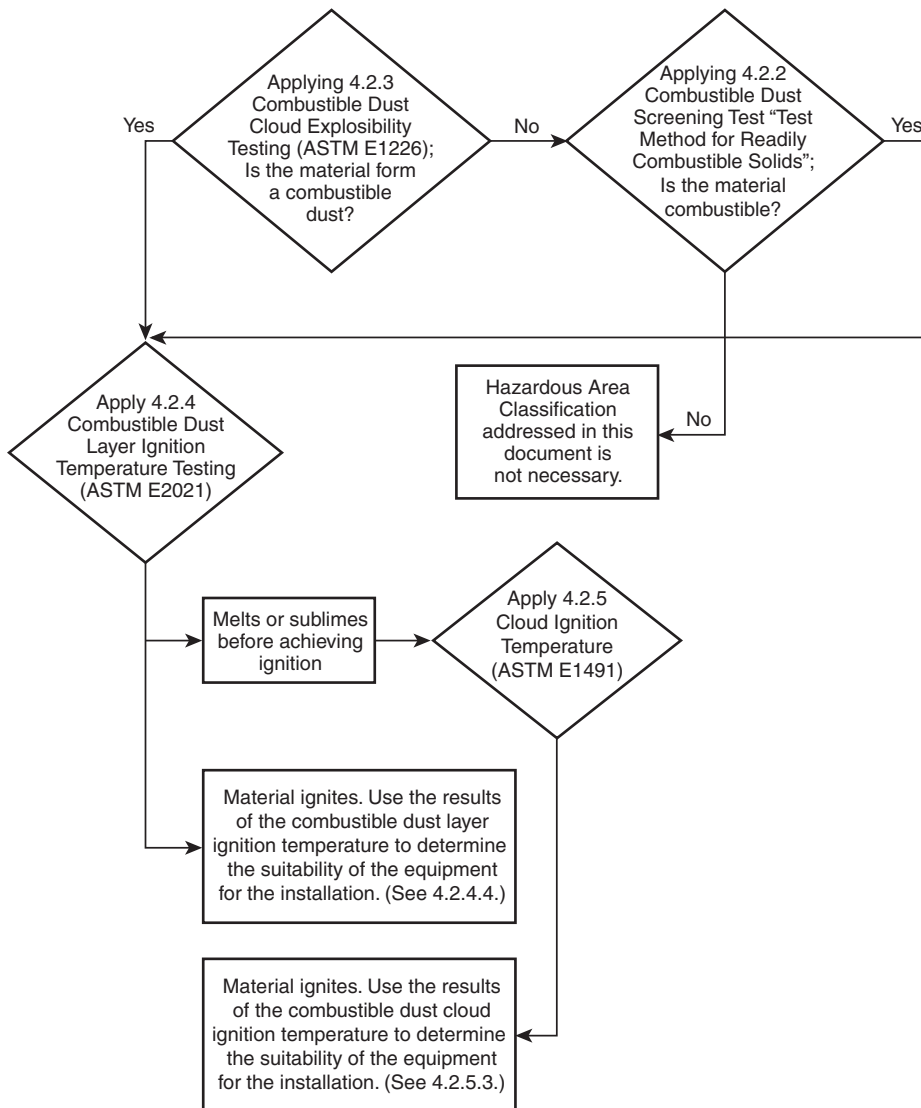
4.1.4.3 Generally, as solid particle size decreases, the layer ignition temperature also decreases, making the combustible dust easier to ignite.

4.1.4.4* The ignition temperature of a layer of organic dust on heat-producing equipment can decrease over time if the dust dehydrates or carbonizes. For such materials, *NFPA 70* specifies that the surface temperature of the heat-producing equipment not exceed the lower of the ignition temperature or 165°C (329°F).

4.1.4.5 Some dusts in layers that melt before reaching their layer ignition temperatures act more like a combustible liquid than a combustible dust. These dusts require additional testing to determine if the cloud ignition temperature is lower than the layer ignition temperature.

4.2 Combustibility and Explosibility Testing.

4.2.1 Testing under this section can be done to verify if the dust is a combustible or explosible dust. Figure 4.2.1 diagrams the combustible dust testing logic.



▲ FIGURE 4.2.1 Material Form Testing.

N 4.2.2 Determination of Combustibility.

N 4.2.2.1 Where the combustibility is not known, determination of the combustibility should be determined by one of the following tests:

- (1) Screening test based on the *UN Recommendations on the Transport of Dangerous Goods: Model Regulations - Manual of Tests and Criteria*, Part III, Subsection 33.2.1, Test N.1 “Test Method for Readily Combustible Solids”
- (2) Other equivalent fire exposure test methods

N 4.2.2.2 For determining combustibility, if the dust in the form tested ignites and then propagates combustion or ejects sparks from the heated zone after the heat source is removed, the material should be considered combustible.

N 4.2.2.3 If the dust is known to be explosible, it should be assumed that the dust is combustible and the recommendations of 4.2.2.1 would not apply.

4.2.3 Combustible Dust Cloud Explosibility Testing.

4.2.3.1 ASTM E1226, *Standard Test Method for Explosibility of Dust Clouds*, should be applied as a screening pass/fail test. This methodology looks at two different cloud concentrations of the material form, 1000 g/m³ and 2000 or more g/m³ (35 oz/ft³ and 70 oz/ft³), which are tested for explosibility within a 20 L (5.3 gal) or larger chamber using a 5 kJ or larger igniter.

4.2.3.2 If either concentration tested under 4.2.3.1 equals or exceeds the ASTM E1226, *Standard Test Method for Explosibility of Dust Clouds*, maximum attained pressure criteria, the sample is conditionally an explosible dust.

4.2.3.3 If both concentrations tested under 4.2.3.1 are less than the ASTM E1226, *Standard Test Method for Explosibility of Dust Clouds*, maximum attained pressure criteria, the sample is likely not an explosible dust.

4.2.4 Combustible Dust Layer Ignition Temperature Testing.

4.2.4.1 This test is necessary to provide design information relating to the surface temperature conditions under which a material form of a particular size and density, when falling out of the air or deposited onto electrical equipment, could heat up above ambient to its layer ignition temperature.

4.2.4.2 The ASTM E2021, *Standard Test Method for Hot-Surface Ignition Temperature of Dust Layers*, test is applied using a hot plate with at least a 12.7 mm (½ in.) dust layer in the material form to verify the ability of a material to absorb heat and lose heat by radiation. At a given surface temperature, a sample will continue to heat and either remain at that temperature or rise to its ignition temperature.

4.2.4.3 If the anticipated material form layer thickness is greater than 12.7 mm (½ in.), the ASTM E2021, *Standard Test Method for Hot-Surface Ignition Temperature of Dust Layers*, test would be performed at this greater thickness to determine the appropriate temperature.

4.2.4.4 If the material ignites, the results of the combustible dust layer ignition temperature test are used to determine the suitability of the equipment for the installation.

4.2.4.5 If the sample fails to ignite at a temperature lower than 450°C (842°F) in the layer ignition test and additionally has been tested and not found to be a combustible dust cloud explosion hazard, the material is not considered to be a combustible dust.

4.2.5 Combustible Dust Cloud Ignition Temperature Testing.

4.2.5.1 Dust in the form of a layer could ignite at significantly lower temperatures than the same dust in the form of a cloud. However, when the dust melts, it could become necessary to test the material form dust to understand if the cloud temperature can become a potential hazard.

4.2.5.2 If the material form sample melts below 450°C (842°F), another sample of the material form should be tested in accordance with ASTM E1491, *Standard Test Method for Minimum Autoignition Temperatures of Dust Clouds*, to determine the cloud ignition temperature.

4.2.5.3* If the material ignites, results of the combustible dust cloud ignition temperature test are used to determine the suitability of the equipment for the installation.

4.3 Additional Potential Combustible Dust Hazards.

4.3.1 Conductive Dusts. Group E dusts can conduct electrical current leading to ignition by spark, by resistive heating, or by causing abnormal operation of the equipment.

4.3.2 Magnesium or Aluminum Dust. Dusts containing magnesium or aluminum are particularly hazardous, and extreme caution should be used to prevent ignition and explosion.

4.4* Hybrid Mixtures. The presence of the flammable gas or vapor, even at concentrations less than their lower flammable limit (LFL), not only will add to the violence of the dust-air combustion but will drastically reduce the ignition energy. This situation is encountered in certain industrial operations, such as fluidized bed dryers and pneumatic conveying systems for plastic dusts from polymerization processes, in which volatile solvents are used. In such cases, electrical equipment should be specified that is suitable for simultaneous exposure to both the

Class I (flammable gas) atmosphere and the Class II (combustible dust) atmosphere.

4.5 Electrostatic Discharges.

4.5.1* Electrostatic discharges are preceded by charge accumulation on insulated surfaces, ungrounded conductors (including human bodies), or particulate materials with high resistivities. The subsequent electrostatic discharge is an ignition threat only if it is sufficiently energetic in comparison to the minimum ignition energy of the pertinent dust cloud.

4.5.2* Control of electrostatics is not addressed within this recommended practice.

4.6 Ignition Criteria.

4.6.1 Layer and dust cloud ignition properties are addressed in this recommended practice by temperature classification codes on equipment.

4.6.2* Potential fire hazards, such as flash fires, and other sources of potential heat, such as hot process surfaces, smoldering nests, self-heating, and friction source, should also be considered independently of the recommended practice.

Chapter 5 National Electrical Code (NEC) Criteria

5.1 Classification of Class II Hazardous Locations and National Electrical Code (NEC) Criteria.

5.1.1 Article 500 of *NFPA 70* establishes the basis for classifying locations where fire or explosion hazards can exist due to flammable gases, flammable liquid-produced vapors, combustible liquid-produced vapors, combustible dusts, or ignitable fibers/flyings.

5.1.2* *NFPA 70* defines a Class II hazardous (classified) location as one that is hazardous because of the presence of a combustible dust.

5.1.3 Class II hazardous (classified) location is further subdivided into either Class II, Division 1 or Class II, Division 2.

5.1.3.1 Class II, Division 1. A Class II, Division 1 location is a location:

- (1) In which combustible dust is in the air under normal operating conditions in quantities sufficient to produce explosive or ignitable mixtures, or
- (2) 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 electrical equipment, through operation of protection devices, or from other causes, or
- (3) In which Group E combustible dusts may be present in quantities sufficient to be hazardous in normal or abnormal operating conditions.

[70:500.5(C)(1)]

5.1.3.2 Class II, Division 2. A Class II, Division 2 location is a location:

- (1) In which combustible dust due to abnormal operations may be present in the air in quantities sufficient to produce explosive or ignitable mixtures; or
- (2) Where combustible dust accumulations are present but are normally insufficient to interfere with the normal operation of electrical equipment or other apparatus, but

could as a result of infrequent malfunctioning of handling or processing equipment become suspended in the air; or

- (3) In which combustible dust accumulations on, in, or in the vicinity of the electrical equipment could be sufficient to interfere with the safe dissipation of heat from electrical equipment, or could be ignitable by abnormal operation or failure of electrical equipment.

[70:500.5(C)(2)]

5.1.4 The intent of Article 500 of *NFPA 70* is to prevent the use of electrical equipment and systems in hazardous (classified) locations that would ignite a combustible dust in either a cloud or layer.

5.1.5 A combustible dust zone hazardous (classified) location is further subdivided into either Zone 20, Zone 21, or Zone 22, in which combustible dust is or might be present in the air or in layers, in quantities sufficient to produce explosive or ignitable mixtures.

5.1.5.1 Zone 20. A Zone 20 location is a location where one of the following may apply:

- (1) Ignitable concentrations of combustible dust, combustible fibers/flyings, or ignitable fibers/flyings are present continuously or for long periods of time.
- (2) Group IIIC combustible dusts are present in hazardous quantities continuously for long periods of time.

[70:506.5(B)(1)]

Δ 5.1.5.2 Zone 21. A Zone 21 location is a location where one of the following apply:

- (1) Ignitable concentrations of combustible dust, combustible fibers/flyings, or ignitable fibers/flyings are likely to exist occasionally under normal operating conditions.
- (2) Ignitable concentrations of combustible dust, combustible fibers/flyings, or ignitable fibers/flyings might exist frequently because of repair or maintenance operations or because of leakage.
- (3) Equipment is operated or processes are carried on of such a nature that equipment breakdown or faulty operations could result in the release of ignitable concentrations of combustible dust, combustible fibers/flyings, or ignitable fibers/flyings and also cause simultaneous failure of electrical equipment in a mode to cause the electrical equipment to become a source of ignition.
- (4) The location is adjacent to a Zone 20 location from which ignitable concentrations of combustible dust, combustible fibers/flyings, or ignitable fibers/flyings could be communicated.
- (5) Group IIIC combustible dusts are present in hazardous quantities occasionally, under normal or abnormal operating conditions, or frequently because of repair or maintenance operations or because of leakage.

[70:506.5(B)(2)]

Δ 5.1.5.3 Zone 22. A Zone 22 location is a location where one of the following apply:

- (1) Ignitable concentrations of combustible dust, combustible fibers/flyings, or ignitable fibers/flyings are not likely to occur in normal operation and, if they do occur, will only persist for a short period.
- (2) Combustible dust, combustible fibers/flyings, or ignitable fibers/flyings are handled, processed, or used, but the dust or fibers/flyings are normally confined within closed

containers of closed systems from which they can escape only as a result of the abnormal operation of the equipment with which the dust or fibers/flyings are handled, processed, or used.

- (3) The location is adjacent to a Zone 21 location, from which ignitable concentrations of combustible dust, combustible fibers/flyings, or ignitable fibers/flyings could be communicated.

[70:506.5(B)(3)]

5.1.6 Electrical installations within hazardous (classified) locations can use various protection techniques. No single protection technique is best in all respects for all types of equipment used in a chemical plant.

5.1.6.1 Dust-ignitionproof electrical equipment, electrical equipment protected by pressurizing, and intrinsically safe electrical equipment are applicable to both Class II, Division 1 and Class II, Division 2 locations.

5.1.6.2 Other dusttight equipment enclosures, as specified in Article 502 of *NFPA 70* are permitted in Class II, Division 2 locations.

5.1.6.3 Electrical equipment protected by pressurizing and intrinsically safe electrical equipment are applicable to both Class II, Division 1 and Class II, Division 2 locations.

Δ 5.1.6.4* Portable electronic products (PEPs) meeting the requirements for PEP-1 or PEP-2 of UL 121203, *Recommended Practice for Portable/Personal Electronic Products Suitable for Use in Class I, Division 2, Class I, Zone 2, Class II, Division 2, Class III, Division 1, Class III, Division 2, Zone 21 and Zone 22 Hazardous (Classified) Locations*, are considered suitable for use in Division 2 and Zone 22 locations.

5.1.6.5 Equipment and wiring suitable for Class I, Division 1 locations are not required and might not be acceptable in Class II locations.

5.1.7 Electrical equipment in Class II, Division 1 locations is enclosed in a manner that will exclude ignitable amounts of dusts or will not permit arcs, sparks, or heat generated or liberated inside the enclosures to cause ignition of dust accumulations or of atmospheric dust suspensions in the vicinity of the equipment.

5.1.8 Electrical equipment in Class II, Division 2 locations is designed so that normal operation of the electrical equipment does not provide a source of ignition.

5.1.8.1 Protection against ignition during electrical breakdown is not provided. However, electrical breakdowns are sufficiently rare that the chances of one occurring simultaneously with accidental release of an ignitable mixture are extremely remote.

5.1.8.2 Arcing and sparking devices are permitted only if suitably enclosed or if the sparks are of insufficient energy to ignite the mixture.

5.1.8.3 Electrical installations in Class II, Division 2 locations should be designed with dusttight enclosures or other equipment enclosures as specified in Article 502 of *NFPA 70*.

5.1.9 Where flammable gases or vapors and combustible dusts are present, electrical equipment and wiring suitable for simultaneous exposure to both Class I and Class II conditions are required.

5.1.10 Factors such as corrosion, weather, maintenance, equipment standardization and interchangeability, and possible process changes or expansion frequently dictate the use of special enclosures or installations for electrical systems. However, such factors are outside the scope of this recommended practice.

5.1.11 For the purpose of this recommended practice, locations not classified as Class II, Division 1 or Class II, Division 2 are “unclassified” locations.

5.2 Classification of Combustible Dusts.

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

5.2.2 Combustible dusts are divided into three groups for zones, depending on the nature of the dust: Group IIIC, Group IIIB, and Group IIIA.

5.2.3* A listing of selected combustible dusts with their group classification and relevant physical properties is provided in Table 5.2.3. The chemicals are listed alphabetically.

5.2.4 Table 5.2.4 provides a cross-reference of selected chemicals sorted by their Chemical Abstract Service (CAS) numbers.

Δ 5.2.5 References that deal with the testing of various characteristics of combustible materials are listed in B.2.1 and B.2.3.

Table 5.2.3 Selected Combustible Dusts

Chemical Name	CAS No.	Division Group/ Zone Group	Code	Layer or Cloud Ignition Temperature (°C)
Acetal, linear		G/IIIB	NL	440
Acetoacet-p-phenetidine	122-82-7	G/IIIB	NL	560
Acetoacetanilide	102-01-2	G/IIIB	M	440
Acetylamino-t-nitrothiazole		G/IIIB		450
Acrylamide polymer		G/IIIB		240
Acrylonitrile polymer		G/IIIB		460
Acrylonitrile-vinyl chloride-vinylidenechloride copolymer (70-20-10)		G/IIIB		210
Acrylonitrile-vinyl pyridine copolymer		G/IIIB		240
Adipic acid	124-04-9	G/IIIB	M	550
Alfalfa meal		G/IIIB		200
Alkyl ketone dimer sizing compound		G/IIIB		160
Allyl alcohol derivative (CR-39)		G/IIIB	NL	500
Almond shell		G/IIIB		200
Aluminum, A422 flake	7429-90-5	E/IIIC		320
Aluminum, atomized collector fines		E/IIIC	CL	550
Aluminum—cobalt alloy (60-40)		E/IIIC		570
Aluminum—copper alloy (50-50)		E/IIIC		830
Aluminum—lithium alloy (15% Li)		E/IIIC		400
Aluminum—magnesium alloy		E/IIIC	CL	430
Aluminum—nickel alloy (58-42)		E/IIIC		540
Aluminum—silicon alloy (12% Si)		E/IIIC	NL	670
Amino-5-nitrothiazole	121-66-4	G/IIIB		460
Anthranilic acid	118-92-3	G/IIIB	M	580
Apricot pit		G/IIIB		230
Aryl-nitrosomethylamide		G/IIIB	NL	490
Asphalt	8052-42-4	F/IIIB		510
Aspirin [acetol (2)]	50-78-2	G/IIIB	M	660
Azelaic acid	109-31-9	G/IIIB	M	610
Azo-bis-butyrionitrile	78-67-1	G/IIIB		350
Benzethonium chloride		G/IIIB	CL	380
Benzoic acid	65-85-0	G/IIIB	M	620
Benzotriazole	95-14-7	G/IIIB	M	440
Beta-naphthalene-axo-dimethylaniline		G/IIIB		175
Bis (2-hydroxy-5-chlorophenyl) methane	97-23-4	G/IIIB	NL	570
Bisphenol-A	80-05-7	G/IIIB	M	570
Boron, commercial amorphous (85% B)	7440-42-8	E/IIIC		400
Calcium silicide		E/IIIC		540
Carbon black (more than 8% total entrapped volatiles)		F/IIIB		
Carboxymethyl cellulose	9000-11-7	G/IIIB		290
Carboxypolymethylene		G/IIIB	NL	520
Cashew oil, phenolic, hard		G/IIIB		180
Cellulose		G/IIIB		260
Cellulose acetate		G/IIIB		340
Cellulose acetate butyrate		G/IIIB	NL	370
Cellulose triacetate		G/IIIB	NL	430
Charcoal (activated)	64365-11-3	F/IIIB		180
Charcoal (more than 8% total entrapped volatiles)		F/IIIB		
Cherry pit		G/IIIB		220
Chlorinated phenol		G/IIIB	NL	570
Chlorinated polyether alcohol		G/IIIB		460
Chloroacetoacetanilide	101-92-8	G/IIIB	M	640
Chromium (97%) electrolytic, milled	7440-47-3	E/IIIC		400
Cinnamon		G/IIIB		230
Citrus peel		G/IIIB		270
Coal, Kentucky bituminous		F/IIIB		180
Coal, Pittsburgh experimental		F/IIIB		170
Coal, Wyoming		F/IIIB		180

(continues)

Table 5.2.3 *Continued*

Chemical Name	CAS No.	Division Group/ Zone Group	Code	Layer or Cloud Ignition Temperature (°C)
Cocoa bean shell		G/IIIB		370
Cocoa, natural, 19% fat		G/IIIB		240
Coconut shell		G/IIIB		220
Coke (more than 8% total entrapped volatiles)		F/IIIB		
Cork		G/IIIB		210
Corn		G/IIIB		250
Corn dextrine		G/IIIB		370
Corn cob grit		G/IIIB		240
Cornstarch, commercial		G/IIIB		330
Cornstarch, modified		G/IIIB		200
Cottonseed meal		G/IIIB		200
Coumarone-indene, hard		G/IIIB	NL	520
Crag No. 974	533-74-4	G/IIIB	CL	310
Cube root, South America	83-79-4	G/IIIB		230
Di-alpha cumyl peroxide, 40-60 on CA	80-43-3	G/IIIB		180
Diallyl phthalate	131-17-9	G/IIIB	M	480
Dicyclopentadiene dioxide		G/IIIB	NL	420
Dieldrin (20%)	60-57-1	G/IIIB	NL	550
Dihydroacetic acid		G/IIIB	NL	430
Dimethyl isophthalate	1459-93-4	G/IIIB	M	580
Dimethyl terephthalate	120-61-6	G/IIIB	M	570
Dinitro-o-toluidine	148-01-6	G/IIIB	NL	500
Dinitrobenzoic acid		G/IIIB	NL	460
Diphenyl	92-52-4	G/IIIB	M	630
Ditertiary-butyl-paracresol	128-37-0	G/IIIB	NL	420
Dithane m-45	8018-01-7	G/IIIB		180
Epoxy		G/IIIB	NL	540
Epoxy-bisphenol A		G/IIIB	NL	510
Ethyl cellulose		G/IIIB	CL	320
Ethyl hydroxyethyl cellulose		G/IIIB	NL	390
Ethylene oxide polymer		G/IIIB	NL	350
Ethylene-maleic anhydride copolymer		G/IIIB	NL	540
Tris(dimethylcarbamodithioato-S,S')iron	14484-64-1	G/IIIB		150
Ferromanganese, medium carbon	12604-53-4	E/IIIC		290
Ferrosilicon (88% Si, 9% Fe)	8049-17-0	E/IIIC		800
Ferrotitanium (19% Ti, 74.1% Fe, 0.06% C)		E/IIIC	CL	380
Flax shive		G/IIIB		230
Fumaric acid	110-17-8	G/IIIB	M	520
Garlic, dehydrated		G/IIIB	NL	360
Gilsonite	12002-43-6	F/IIIB		500
Green base harmon dye		G/IIIB		175
Guar seed		G/IIIB	NL	500
Gulonic acid, diacetone		G/IIIB	NL	420
Gum, arabic		G/IIIB		260
Gum, karaya		G/IIIB		240
Gum, manila		G/IIIB	CL	360
Gum, tragacanth	9000-65-1	G/IIIB		260
Hemp hurd		G/IIIB		220
Hexamethylene tetramine	100-97-0	G/IIIB	S	410
Hydroxyethyl cellulose		G/IIIB	NL	410
Iron, 98% H ₂ reduced		E/IIIC		290
Iron, 99% carbonyl	13463-40-6	E/IIIC		310
Isotoic anhydride		G/IIIB	NL	700
L-sorbose		G/IIIB	M	370
Lignin, hydrolyzed, wood-type, fine		G/IIIB	NL	450
Lignite, California		F/IIIB		180
Lycopodium		G/IIIB		190
Malt barley		G/IIIB		250

(continues)

Table 5.2.3 *Continued*

Chemical Name	CAS No.	Division Group/ Zone Group	Code	Layer or Cloud Ignition Temperature (°C)
Manganese	7439-96-5	E/IIIC		240
Magnesium, grade B, milled		E/IIIC		430
Manganese vancide		G/IIIB		120
Mannitol	69-65-8	G/IIIB	M	460
Methacrylic acid polymer		G/IIIB		290
Methionine (l-methionine)	63-68-3	G/IIIB		360
Methyl cellulose		G/IIIB		340
Methyl methacrylate polymer	9011-14-7	G/IIIB	NL	440
Methyl methacrylate-ethyl acrylate		G/IIIB	NL	440
Methyl methacrylate-styrene-butadiene		G/IIIB	NL	480
Milk, skimmed		G/IIIB		200
N,N-dimethylthio-formamide		G/IIIB		230
Nitropyridone	100703-82-0	G/IIIB	M	430
Nitrosamine		G/IIIB	NL	270
Nylon polymer	63428-84-2	G/IIIB		430
Para-oxy-benzaldehyde	123-08-0	G/IIIB	CL	380
Paraphenylene diamine	106-50-3	G/IIIB	M	620
Paratertiary butyl benzoic acid	98-73-7	G/IIIB	M	560
Pea flour		G/IIIB		260
Peach pit shell		G/IIIB		210
Peanut hull		G/IIIB		210
Peat, sphagnum	94114-14-4	G/IIIB		240
Pecan nut shell	8002-03-7	G/IIIB		210
Pectin	5328-37-0	G/IIIB		200
Pentaerythritol	115-77-5	G/IIIB	M	400
Petrin acrylate monomer	7659-34-9	G/IIIB	NL	220
Petroleum coke (more than 8% total entrapped volatiles)		F/IIIB		
Petroleum resin	64742-16-1	G/IIIB		500
Phenol formaldehyde	9003-35-4	G/IIIB	NL	580
Phenol formaldehyde, polyalkylene-p	9003-35-4	G/IIIB		290
Phenol furfural	26338-61-4	G/IIIB		310
Phenylbetanaphthylamine	135-88-6	G/IIIB	NL	680
Phthalic anhydride	85-44-9	G/IIIB	M	650
Phthalimide	85-41-6	G/IIIB	M	630
Pitch, coal tar	65996-93-2	F/IIIB	NL	710
Pitch, petroleum	68187-58-6	F/IIIB	NL	630
Polycarbonate		G/IIIB	NL	710
Polyethylene, high pressure process	9002-88-4	G/IIIB		380
Polyethylene, low pressure process	9002-88-4	G/IIIB	NL	420
Polyethylene terephthalate	25038-59-9	G/IIIB	NL	500
Polyethylene wax	68441-04-8	G/IIIB	NL	400
Polypropylene (no antioxidant)	9003-07-0	G/IIIB	NL	420
Polystyrene latex	9003-53-6	G/IIIB		500
Polystyrene molding compound	9003-53-6	G/IIIB	NL	560
Polyurethane foam, fire retardant	9009-54-5	G/IIIB		390
Polyurethane foam, no fire retardant	9009-54-5	G/IIIB		440
Polyvinyl acetate	9003-20-7	G/IIIB	NL	550
Polyvinyl acetate/alcohol	9002-89-5	G/IIIB		440
Polyvinyl butyral	63148-65-2	G/IIIB		390
Polyvinyl chloride-diethyl phthalate		G/IIIB	NL	320
Potato starch, dextrinated	9005-25-8	G/IIIB	NL	440
Pyrethrum	8003-34-7	G/IIIB		210
Rayon (viscose) flock	61788-77-0	G/IIIB		250
Red dye intermediate		G/IIIB		175
Rice		G/IIIB		220
Rice bran		G/IIIB	NL	490
Rice hull		G/IIIB		220
Rosin, DK	8050-09-7	G/IIIB	NL	390

(continues)

Table 5.2.3 *Continued*

Chemical Name	CAS No.	Division Group/ Zone Group	Code	Layer or Cloud Ignition Temperature (°C)
Rubber, crude, hard	9006-04-6	G/IIIB	NL	350
Rubber, synthetic, hard (33% S)	64706-29-2	G/IIIB	NL	320
Safflower meal		G/IIIB		210
Salicylanilide	87-17-2	G/IIIB	M	610
Sevin	63-25-2	G/IIIB		140
Shale, oil	68308-34-9	F/IIIB		
Shellac	9000-59-3	G/IIIB	NL	400
Sodium resinate	61790-51-0	G/IIIB		220
Sorbic acid (copper sorbate or potash)	110-44-1	G/IIIB		460
Soy flour	68513-95-1	G/IIIB		190
Soy protein	9010-10-0	G/IIIB		260
Stearic acid, aluminum salt	637-12-7	G/IIIB		300
Stearic acid, zinc salt	557-05-1	G/IIIB	M	510
Styrene modified polyester-glass fiber	100-42-5	G/IIIB		360
Styrene-acrylonitrile (70-30)	9003-54-7	G/IIIB	NL	500
Styrene-butadiene latex (>75% styrene)	903-55-8	G/IIIB	NL	440
Styrene-maleic anhydride copolymer	9011-13-6	G/IIIB	CL	470
Sucrose	57-50-1	G/IIIB	CL	350
Sugar, powdered	57-50-1	G/IIIB	CL	370
Sulfur	7704-34-9	G/IIIB		220
Tantalum	7440-25-7	E/IIIC		300
Terephthalic acid	100-21-0	G/IIIB	NL	680
Thorium (contains 1.2% O)	7440-29-1	E/IIIC	CL	270
Tin, 96%, atomized (2% Pb)	7440-31-5	E/IIIC		430
Titanium, 99% Ti	7440-32-6	E/IIIC	CL	330
Titanium hydride (95% Ti, 3.8% H)	7704-98-5	E/IIIC	CL	480
Trithiobisdimethylthio-formamide		G/IIIB		230
Tung, kernels, oil-free	8001-20-5	G/IIIB		240
Urea formaldehyde molding compound	9011-05-6	G/IIIB	NL	460
Urea formaldehyde-phenol formaldehyde	25104-55-6	G/IIIB		240
Vanadium, 86.4%	7440-62-2	E/IIIC		490
Vinyl chloride-acrylonitrile copolymer	9003-00-3	G/IIIB		470
Vinyl toluene-acrylonitrile butadiene	76404-69-8	G/IIIB	NL	530
Violet 200 dye		G/IIIB		175
Vitamin B1, mononitrate	59-43-8	G/IIIB	NL	360
Vitamin C	50-81-7	G/IIIB		280
Walnut shell, black		G/IIIB		220
Wheat		G/IIIB		220
Wheat flour	130498-22-5	G/IIIB		360
Wheat gluten, gum	100684-25-1	G/IIIB	NL	520
Wheat starch		G/IIIB	NL	380
Wheat straw		G/IIIB		220
Wood flour		G/IIIB		260
Woodbark, ground		G/IIIB		250
Yeast, torula	68602-94-8	G/IIIB		260
Zirconium hydride	7704-99-6	E/IIIC		270
Zirconium (contains 0.3% O)	7440-67-7	E/IIIC	CL	330

Notes:

(1) Normally, the minimum ignition temperature of a layer of a specific dust is lower than the minimum ignition temperature of a cloud of that dust. Because this is not universally true, the lower of the two minimum ignition temperatures is listed. If no symbol appears in the "Code" column, then the layer ignition temperature is shown. "CL" means the cloud ignition temperature is shown. "NL" means that no layer ignition temperature is available, and the cloud ignition temperature is shown. "M" signifies that the dust layer melts before it ignites; the cloud ignition temperature is shown. "S" signifies that the dust layer sublimates before it ignites; the cloud ignition temperature is shown.

(2) Certain metal dusts might have characteristics that necessitate safeguards beyond those needed for atmospheres containing the dusts of aluminum, magnesium, and their commercial alloys. For example, zirconium and thorium dusts can ignite spontaneously in air, especially at elevated temperatures.

(3) Combustible metal fibers/flyings, as defined in 3.3.4.1, are Group E/IIIC materials.

(4) Due to the impurities found in coal, its ignition temperatures vary regionally, and ignition temperatures are not available for all regions in which coal is mined.

Table 5.2.4 Cross-Reference of Chemical CAS Number to Chemical Name

CAS No.	Chemical Name
50-78-2	Aspirin [acetol (2)]
50-81-7	Vitamin C
57-50-1	Sucrose
57-50-1	Sugar, powdered
59-43-8	Vitamin B1, mononitrate
60-57-1	Dieldrin (20%)
63-25-2	Sevin
63-68-3	Methionine (l-methionine)
65-85-0	Benzoic acid
69-65-8	Mannitol
78-67-1	Azo-bis-butyronitrile
80-05-7	Bisphenol-A
80-43-3	Di-alpha-cumyl peroxide, 40-60 on CA
83-79-4	Cube root, South America
85-41-6	Phthalimide
85-44-9	Phthalic anhydride
87-17-2	Salicylanilide
92-52-4	Diphenyl
95-14-7	Benzotriazole
97-23-4	Bis(2-hydroxy-5-chlorophenyl) methane
98-73-7	Paratertiary butyl benzoic acid
100-21-0	Terephthalic acid
100-42-5	Styrene modified polyester-glass fiber
100-97-0	Hexamethylene tetramine
101-92-8	Chloroacetoacetanilide
102-01-2	Acetoacetanilide
106-50-3	Paraphenylene diamine
109-31-9	Azelaic acid
110-17-8	Fumaric acid
110-44-1	Sorbic acid (copper sorbate or potash)
115-77-5	Pentaerythritol
118-92-3	Anthranilic acid
120-61-6	Dimethyl terephthalate
121-66-4	Amino-5-nitrothiazole
122-82-7	Acetoacet-p-phenetide
123-08-0	Para-oxy-benzaldehyde
124-04-9	Adipic acid
128-37-0	Ditertiary-butyl-paracresol
131-17-9	Diallyl phthalate
135-88-6	Phenylbetanaphthylamine
148-01-6	Dinitro-o-toluamide
533-74-4	Crag No. 974
557-05-1	Stearic acid, zinc salt
637-12-7	Stearic acid, aluminum salt
903-55-8	Styrene-butadiene latex (>75% styrene)
1459-93-4	Dimethyl isophthalate
5328-37-0	Pectin
7429-90-5	Aluminum, A422 flake
7439-96-5	Manganese
7440-25-7	Tantalum
7440-29-1	Thorium, 1.2% O ₂
7440-31-5	Tin, 96, atomized (2% Pb)
7440-32-6	Titanium, 99% Ti
7440-42-8	Boron, commercial amorphous (85% B)
7440-47-3	Chromium (97%) electrolytic, milled
7440-62-2	Vanadium, 86.4%
7659-34-9	Petrin acrylate monomer
7704-34-9	Sulfur

(continues)

Table 5.2.4 *Continued*

CAS No.	Chemical Name
7704-98-5	Titanium hydride (95% Ti, 3.8% H ₂)
7704-99-6	Zirconium hydride
8001-20-5	Tung, kernels, oil-free
8002-03-7	Pecan nut shell
8003-34-7	Pyrethrum
8018-01-7	Dithane M-45
8049-17-0	Ferrosilicon (88% Si, 9% Fe)
8050-09-7	Rosin, DK
8052-42-4	Asphalt
9000-11-7	Carboxymethyl cellulose
9000-59-3	Shellac
9000-65-1	Gum, tragacanth
9002-88-4	Polyethylene, high pressure process
9002-88-4	Polyethylene, low pressure process
9002-89-5	Polyvinyl acetate/alcohol
9003-00-3	Vinyl chloride-acrylonitrile copolymer
9003-07-0	Polypropylene (no antioxidant)
9003-20-7	Polyvinyl acetate
9003-35-4	Phenol formaldehyde
9003-35-4	Phenol formaldehyde, polyalkylene-p
9003-53-6	Polystyrene latex
9003-53-6	Polystyrene molding compound
9003-54-7	Styrene-acrylonitrile (70-30)
9005-25-8	Potato starch, dextrinated
9006-04-6	Rubber, crude, hard
9009-54-5	Polyurethane foam, fire retardant
9009-54-5	Polyurethane foam, no fire retardant
9010-10-0	Soy protein
9011-05-6	Urea formaldehyde molding compound
9011-13-6	Styrene-maleic anhydride copolymer
9011-14-7	Methyl methacrylate polymer
12002-43-6	Gilsonite
12604-53-4	Ferromanganese, medium carbon
13463-40-6	Iron, 99% carbonyl
14484-64-1	Tris(dimethylcarbamodithioato-S,S')iron
25038-59-9	Polyethylene terephthalate
25104-55-6	Urea formaldehyde-phenol formaldehyde
26338-61-4	Phenol furfural
61788-77-0	Rayon (viscose) flock
61790-51-0	Sodium resinate
63148-65-2	Polyvinyl butyral
63428-84-2	Nylon polymer
64365-11-3	Charcoal (activated)
64706-29-2	Rubber, synthetic, hard (33% S)
64742-16-1	Petroleum resin
65996-93-2	Pitch, coal tar
68187-58-6	Pitch, petroleum
68308-34-9	Shale, oil
68441-04-8	Polyethylene wax
68513-95-1	Soy flour
68602-94-8	Yeast, torula
76404-69-8	Vinyl toluene-acrylonitrile butadiene
94114-14-4	Peat, sphagnum
100684-25-1	Wheat gluten, gum
100703-82-0	Nitropyridone
130498-22-5	Wheat flour

Chapter 6 Classification of Combustible Dust Locations

6.1 General.

6.1.1 A location is classified based on the probability that a combustible dust could be present.

6.1.2 The degree of hazard determines whether the location is classified as Class II, Division 1; Class II, Division 2; Class III, Division 1; Class III, Division 2; Zone 20; Zone 21; Zone 22; or unclassified.

6.1.3* Where atmospheres contain Group IIIA materials, the classification diagrams for Group IIIB should be applied to determine the extent of the hazardous (classified) location. The location should be Zone 20, Zone 21, or Zone 22, as appropriate.

6.2* Conditions Necessary for Ignition of Combustible Dust.

6.2.1 In a combustible dust location, one of the sets of conditions in 6.2.1.1 through 6.2.1.3 must be satisfied for ignition by the electrical installation.

6.2.1.1 In the first set of conditions, the following conditions exist:

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

6.2.1.2* In the second set of conditions, the following conditions exist:

- (1) A combustible dust is present.
- (2) The dust is 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 is high enough to cause the dust to reach its ignition temperature directly or to dry out the dust and cause it to self-heat.

6.2.1.3 In the third set of conditions, the following conditions exist:

- (1) A combustible metal dust (i.e., Group E or Group IIIC) dust is present.
- (2) The dust is layered or in suspension in hazardous quantities.
- (3) Current through the dust is sufficient to cause ignition.

6.2.2 Once ignition has occurred, either in a cloud suspension or in a layer, an explosion is likely.

6.2.2.1 Often, the initial explosion is followed by another much more violent explosion fueled from dust accumulations on structural beams and equipment surfaces that are thrown into suspension by the initial blast.

6.2.2.2 Due to the explosion hazard in 6.2.2.1, good housekeeping is vitally important in all areas where dust is handled and is assumed throughout this recommended practice.

6.2.3 In classifying a particular location, the presence of a combustible dust is significant in determining the correct division.

6.2.3.1 The classification depends on the presence of either dust clouds or hazardous accumulations of dust in layer form.

6.2.3.2 The presence of a combustible dust cloud under normal conditions of operation or due to frequent repair or maintenance should be classified as in Class II, Division 1, or Zone 20/Zone 21.

6.2.3.3 Abnormal operation of machinery and equipment, which could simultaneously produce a dust cloud and a source of ignition, should be classified as Class II, Division 1, or Zone 20/Zone 21.

6.2.3.4 Per 6.2.3.2 and 6.2.3.3, if a dust cloud is present at any time, it is assumed to be ignitable, and all that is necessary for electrical ignition is failure of the electrical system.

6.2.3.5 If Group F or G materials are present in quantities sufficient to be hazardous only as a result of infrequent malfunctioning of handling or processing equipment, and ignition can result only from abnormal operation or failure of electrical equipment, the location should be classified Class II, Division 2. If Group IIIB materials or Group IIIA materials are present in quantities sufficient to be hazardous only as a result of infrequent malfunctioning of handling or processing equipment, and ignition can result only from abnormal operation or failure of electrical equipment, the location should be classified Zone 22.

6.2.3.6 If Group E or Group IIIC materials are present in quantities sufficient to be hazardous, a location that would otherwise be considered Class II, Division 2 or Zone 22, respectively, should be classified Class II, Division 1 or Zone 21, respectively.

6.2.4 The presence of an ignitable dust cloud or an ignitable dust layer is important in determining the boundaries of the hazardous (classified) location.

6.2.5 The quantity of dust, its physical and chemical properties, its dispersion properties, and the location of walls and cutoffs all must be considered.

6.3 Class II, Division 1 or Zone 20/Zone 21 Classified Locations.

6.3.1 Where a combustible dust cloud is likely to be present under normal conditions, the location should be classified as Class II, Division 1 or Zone 20/Zone 21.

6.3.1.1 This practice does not support a design that permits a normal continued condition of more than the tested layer thickness (*see 4.2.4.3*) of dust accumulation nor presence of greater than moderate isolated dust cloud, external to processing equipment.

6.3.2* Where a dust layer greater than 3.0 mm ($\frac{1}{8}$ in.) thick is present under normal conditions, the location should be classified as Class II, Division 1 or Zone 20/Zone 21.

6.3.3 The term *normal* does not necessarily mean the situation that prevails when everything is working properly.

6.3.3.1 For example, if a bucket elevator requires frequent maintenance and repair, this repair should be viewed as normal.

6.3.3.2 If quantities of ignitable dust are released as a result of the maintenance, the location is Class II, Division 1 or Zone 20/Zone 21.

6.3.3.3 However, if that bucket elevator is replaced and now repairs are not usually required between turnarounds, the need for repairs is considered abnormal.

6.3.3.4 The classification of the location, therefore, is related to equipment maintenance, both procedures and frequencies.

6.3.3.5 Similarly, if the problem is the buildup of dust layers without the presence of visible dust suspensions, good and frequent cleaning procedures, or lack thereof, will influence the classification of the location.

6.4 Combustible Dust, Class II, Division 2 or Zone 22, Classified Locations.

6.4.1 The criterion for a Class II, Division 2 or Zone 22 location is whether the location is likely to have ignitable dust suspensions or hazardous dust accumulations only under abnormal conditions. The term *abnormal* is used here in a limited sense and does not include a major catastrophe.

6.4.2 As an example, consider the replaced bucket elevator of 6.3.3.1, which releases ignitable dust only under abnormal conditions. In this case, there is no Class II, Division 1 or Zone 20/Zone 21 location because the elevator is normally tight. To release dust, the elevator would have to leak, and that would not be normal.

6.4.3 Chemical process equipment does not fail often. Furthermore, the electrical installation requirement of the *NFPA 70* for Class II, Division 2 or Zone 22 locations is such that an ignition-capable spark or hot surface will occur only in the event of abnormal operation or failure of electrical equipment. Otherwise, sparks and hot surfaces are not present or are contained in enclosures. On a realistic basis, the possibility of process equipment and electrical equipment failing simultaneously is remote.

6.4.4 The Class II, Division 2 and the Zone 22 classification is applicable to conditions not involving equipment failure. For example, consider a location classified as Class II, Division 1 because of normal presence of ignitable dust suspension. Obviously, one side of the Class II, Division 1 boundary cannot be normally hazardous and the opposite side never hazardous. Similarly, consider a location classified as Class II, Division 1 because of the normal presence of hazardous dust accumulations. One side of the division boundary cannot be normally hazardous, with thick layers of dust, and the other side unclassified, with no dust, unless there is an intervening wall.

6.4.5 Where there is no wall, a surrounding transition Class II, Division 2 or Zone 22 location separates a Class II, Division 1 or Zone 20/Zone 21 location from an unclassified location. For Group E or Group IIIC combustible metal dusts that might be present in quantities sufficient to be hazardous, the surrounding transition can be applied as is an additional Class II, Division 1 or Zone 20/Zone 21 location.

6.4.6 Walls are much more important in separating Class II, Division 1 or Zone 20/Zone 21 locations from Class II, Division 2 or Zone 22 and unclassified locations in Class II locations than in Class I locations.

6.4.6.1 Only unpierced solid walls make satisfactory barriers in Class I locations, whereas closed doors, lightweight partitions,

or even partial partitions could make satisfactory walls between Class II, Division 1 or Zone 20/Zone 21 locations and unclassified locations.

6.4.6.2 Area classification does not extend beyond the wall, provided it is effective in preventing the passage of dust in suspension or layer form.

6.5 Unclassified Locations.

6.5.1 Experience has shown that the release of ignitable dust suspensions from some operations and apparatus is so infrequent that area classification is not necessary. For example, where combustible dusts are processed, stored, or handled, it is usually not necessary to classify the following locations:

- (1) Where materials are stored in sealed containers (e.g., bags, drums, or fiber packs on pallets or racks)
- (2) Where materials are transported in well-maintained closed piping systems
- (3) Where palletized materials with minimal dust are handled or used
- (4) Where closed tanks are used for storage and handling
- (5) Where dust removal systems prevent the following:
 - (a) Visual dust clouds
 - (b) Layer accumulations that make surface colors indiscernible (*see A.6.3.2*)
- (6) Where excellent housekeeping prevents the following:
 - (a) Visual dust clouds
 - (b) Layer accumulations that make surface colors indiscernible (*see A.6.3.2*)

6.5.2 Dust removal systems that are provided to allow an unclassified location should have adequate safeguards and warnings against failure.

6.5.3 Open flames and hot surfaces associated with the operation of certain equipment, such as boilers and fired heaters, provide inherent thermal ignition sources.

6.5.3.1 Area classification is not appropriate in the immediate vicinity of inherent thermal ignition sources.

6.5.3.2 Dust-containing operations should be cut off by blank walls or located away from inherent thermal ignition sources.

6.5.3.3 Where pulverized coal or ground-up solid waste is used to fire a boiler or incinerator, it is prudent to avoid installing electrical equipment that could become primary ignition sources for leaks in the fuel feed lines.

6.6 Procedure for Classifying Areas. Subsections 6.6.1 through 6.6.4 detail the procedure that should be used for each room, section, or area being classified.

6.6.1 Step 1: Need for Classification. The area should be classified if a combustible material is processed, handled, or stored there.

6.6.2 Step 2: Gathering Information.

6.6.2.1 Proposed Facility Information. For a proposed facility that exists only in drawings, a preliminary area classification can be done so that suitable electrical equipment and instrumentation can be purchased. Plants are rarely built exactly as the drawings portray, and the area classification should be modified later, based on the actual facility.

6.6.2.2 Existing Facility History. For an existing facility, the individual plant experience is extremely important in classify-

ing areas within the plant. Both operation and maintenance personnel in the actual plant should be asked the following questions:

- (1) Is a dust likely to be in suspension in air continuously, periodically, or intermittently under normal conditions in quantities sufficient to produce an ignitable mixture?
- (2) Are there dust layers or accumulations on surfaces deeper than 3.0 mm ($\frac{1}{8}$ in.)?
- (3) Are there dust layers or accumulations on surfaces that make the colors of the floor or equipment surfaces indiscernible?
- (4) What is the dust accumulation after 24 hours?
- (5) Is the equipment in good condition, in questionable condition, or in need of repair? Are equipment enclosures in good repair, and do they prevent the entrance of dust?
- (6) Do maintenance practices result in the formation of ignitable mixtures?
- (7) What equipment is used for dust collection?

6.6.2.3 Material Density. The specific particle density of the dust should be determined if it is at least 641 kg/m³ (40 lb/ft³).

6.6.2.4 Plot Plan. A plot plan (or similar drawing) is needed that shows all vessels, tanks, building structures, partitions, and similar items that would affect dispersion or promote accumulation of the dust.

6.6.2.5 Fire Hazard Properties of Combustible Material. The NEC group and the layer or cloud ignition temperature are shown in Table 5.2.3 for many materials.

6.6.2.5.1 A material could be listed in Table 5.2.3 under a chemical name different from the chemical name used at the facility. Table 5.2.4 is provided to cross-reference the CAS number of the material to the chemical name used in Table 5.2.3.

6.6.2.5.2 Where materials being used are not listed in Table 5.2.3 or in other reputable chemical references, the information needed to classify the area can be obtained by one of the following methods:

- (1) Contacting the material supplier to determine if the material has been group classified and if the autoignition temperature has been determined
- (2) Having the material evaluated for the group and tested for the autoignition temperature

6.6.3 Step 3: Selecting the Appropriate Classification Diagram. The appropriate diagrams should be selected based on the following:

- (1) Whether the process equipment is open or enclosed
- (2) Whether the dust is Class II; Group E, F, or G; or for Zones Group IIIC or IIIB/IIIA
- (3) Whether the area is for storage

6.6.4 Step 4: Determining the Extent of the Hazardous (Classified) Location. The extent of the hazardous (classified) location can be determined using sound engineering judgment to apply the methods discussed in Section 5.1 and the diagrams contained in this chapter.

6.6.4.1 The potential sources of leaks should be located on the plan drawing or at the actual location. These sources of leaks could include rotating or reciprocating shafts, doors and covers on process equipment, and so forth.

6.6.4.2 For each leakage source, an equivalent example on the selected classification diagram should be located to determine the minimum extent of classification around the leakage source. The extent can be modified by considering the following:

- (1) Whether an ignitable mixture is likely to occur frequently due to repair, maintenance, or leakage
- (2) Where conditions of maintenance and supervision are such that leaks are likely to occur in process equipment, storage vessels, and piping systems containing combustible material
- (3) Ventilation or prevailing wind in the specific area and the dispersion rates of the combustible materials

6.6.4.3 Once the minimum extent is determined, for practical reasons distinct landmarks (e.g., curbs, dikes, walls, structural supports, edges of roads) should be utilized for the actual boundaries of the area classification. Landmarks permit identification of the boundaries of the hazardous (classified) locations for electricians, instrument technicians, operators, and other personnel.

6.7* Housekeeping. Housekeeping frequency [see Table A.6.7(a) and Table A.6.7(b)] and effectiveness are significant factors in the presence and control of dust accumulations.

6.8 Extent of Hazardous (Classified) Locations.

6.8.1 Careful consideration of the following factors is necessary in determining the extent of the locations:

- (1) Combustible material involved
- (2) Bulk density of the material
- (3) Particle sizes of the material
- (4) Particle density
- (5) Process or storage pressure
- (6) Size of the leak opening
- (7) Quantity of the release
- (8) Dust removal system
- (9) Housekeeping
- (10) Presence of any hybrid mixture

6.8.2 The dispersal of dusts and the influence of the factors in 6.8.1 on this dispersal are discussed generally in 4.1.3. The importance of dust removal and housekeeping are discussed in other paragraphs of this chapter.

6.8.3 In addition, walls, partitions, enclosures, or other barriers and strong air currents will also affect the distance that dust particles will travel and the extent of the Class II, Division 1 or Zone 20/Zone 21 and Class II, Division 2 or Zone 22 locations.

6.8.4 Where there are walls that limit the travel of the dust particles, area classifications do not extend beyond the walls. Providing walls and partitions is a primary means of limiting the extent of hazardous (classified) locations.

6.8.5 Where effective walls are not provided, the extent of the Class II, Division 1 or Zone 20/Zone 21 and Class II, Division 2 or Zone 22 locations can be estimated as follows:

- (1) By visual observation of the existing location using the guidelines in A.6.3.2
- (2) By experience with similar dusts and similar operations and by taking into consideration differences in equipment, enclosures, dust-removal systems, and housekeeping rules and methods
- (3) By using the classification diagrams in this chapter

6.8.6 Tight equipment, ventilated hoods and pickup points, good maintenance, and good housekeeping practices should limit Class II, Division 1 or Zone 20/Zone 21 locations to those inside process enclosures and equipment and those close to openings necessary for transfer of material, as from conveyors to grinders to storage bins to bags. Similarly, the same factors will also limit the Class II, Division 2 and Zone 22 location surrounding the Class II, Division 1 or Zone 20/Zone 21 location.

6.8.7 The size of a building and its walls will influence the classification of the enclosed volume. In the case of a small room, it can be appropriate to classify the entire volume as Class II, Division 1 or Zone 20/Zone 21 or Class II, Division 2 or Zone 22.

6.8.8 When classifying large buildings, careful evaluation of prior experience with the same or similar installations should be made. Where experience indicates that a particular design concept is sound, that design should continue to be followed. Sound engineering judgment and good housekeeping should be used to minimize the extent of hazardous (classified) locations.

6.8.8.1 Wherever possible with large buildings, walls should be used to cut off dusty operations to minimize the hazardous (classified) location. Where walls are not possible, the concentric volume approach of a Class II, Division 1 or Zone 20/Zone 21 location surrounded by a larger Class II, Division 2 or Zone 22 location, should be used as shown in the diagrams in Section 6.10. [See Figure 6.10(a).]

6.8.8.2 Where it is necessary to have a number of dusty operations located in a building, there could be a multiplicity of Class II, Division 1 or Zone 20/Zone 21 locations, with intervening Class II, Division 2 or Zone 22 and unclassified locations.

6.8.9 The quantity of dust released and its distance of travel are of extreme importance in determining the extent of a hazardous (classified) location. This determination requires sound engineering judgment. However, one cannot lose sight of the purpose of this judgment; the location is classified solely for the installation of electrical equipment.

6.9 Discussion of Diagrams and Recommendations.

6.9.1 The series of diagrams in Section 6.10 illustrate how typical dusty areas should be classified and the recommended extent of classification.

6.9.2 The diagrams should be used as aids in developing electrical classification maps of operating units, storage areas, and process buildings. Most of the maps will be plan views. However, elevations could be necessary to provide the three-dimensional picture of an actual operation.

6.9.3 An operating unit could have many interconnected sources of combustible material, such as storage tanks, bins and silos, piping and ductwork, hammer mills, ball mills, grinders, pulverizers, milling machines, conveyors, bucket elevators, and bagging or other packaging machines. These in turn present sources of leaks, such as flanged and screwed connections, fittings, openings, valves, and metering and weighing devices. Thus, actual diagrams of the equipment could be required so that the necessary engineering judgment to establish the boundaries of Class II, Division 1 or Zone 20/Zone 21 and Class II, Division 2 or Zone 22 locations can be applied.

6.9.4 These diagrams apply to operating equipment processing dusts when the specific particle density is greater than 641 kg/m^3 (40 lb/ft^3). When dusts with a specific particle density less than 641 kg/m^3 (40 lb/ft^3) are being handled, there is a pronounced tendency for the fine dust to drift on air currents normally present in industrial plants for distances considerably farther than those shown on these diagrams. In those cases, it will be necessary to extend the hazardous (classified) location using sound engineering judgment and experience.

6.9.5 Good engineering practices, good housekeeping practices, and effective dust removal systems are necessary to limit the extent of the classified areas and to minimize the chances of primary explosions and secondary explosions, which are often more violent.

6.10 Classification Diagrams. The classification diagrams shown in Figure 6.10(a) through Figure 6.10(r) assume that the specific particle density is greater than 641 kg/m^3 (40 lb/ft^3).

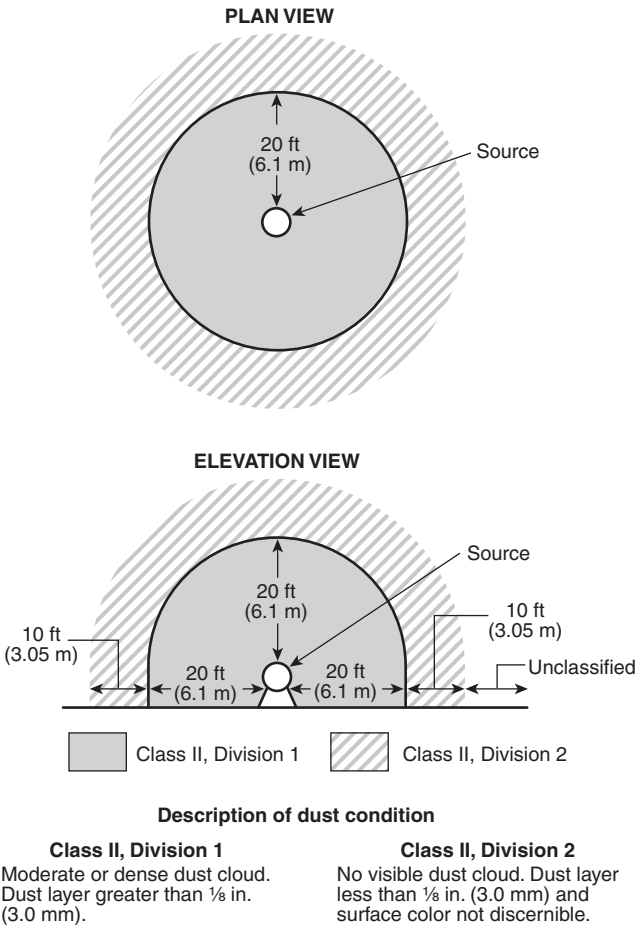


FIGURE 6.10(a) Group F or Group G Dust — Indoor, Unrestricted Area; Open or Semi-Enclosed Operating Equipment.

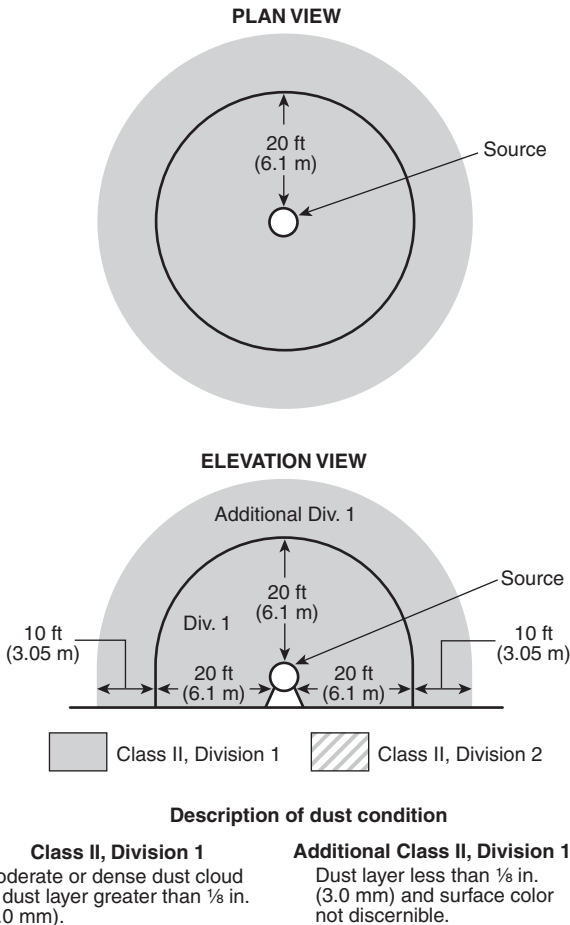
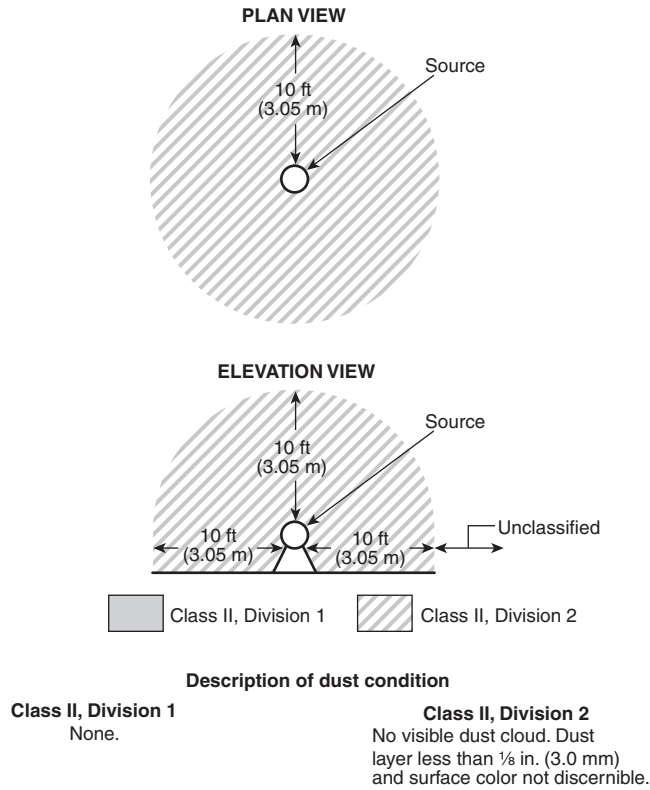
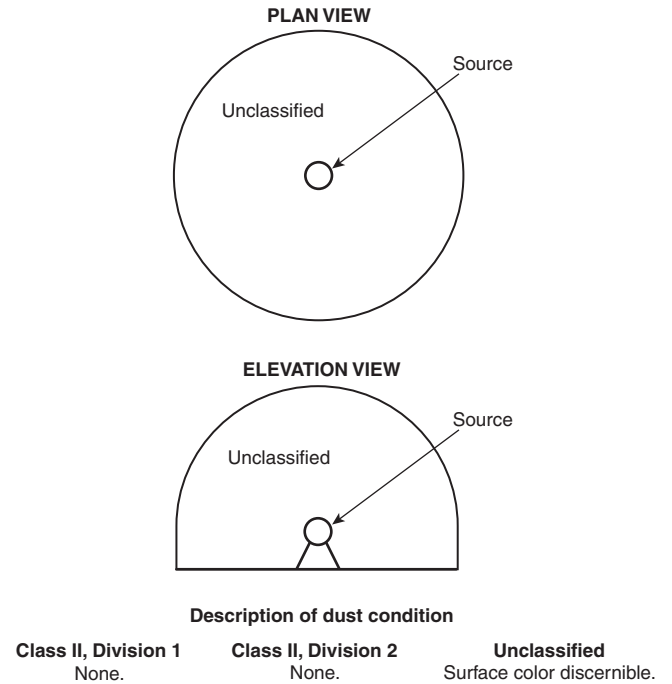


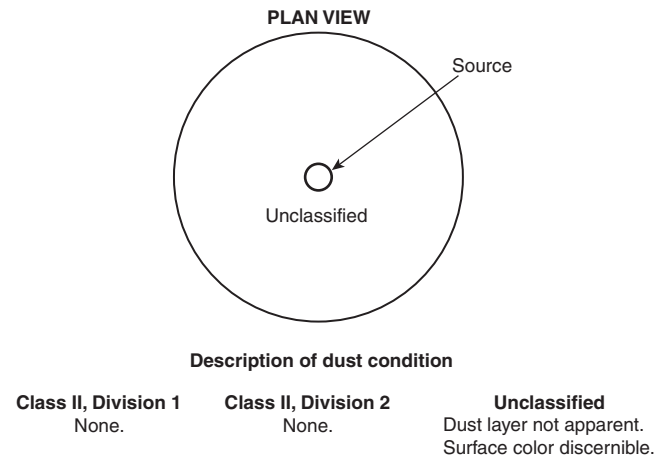
FIGURE 6.10(b) Group E Dust — Indoor, Unrestricted Area; Open or Semi-Enclosed Operating Equipment.



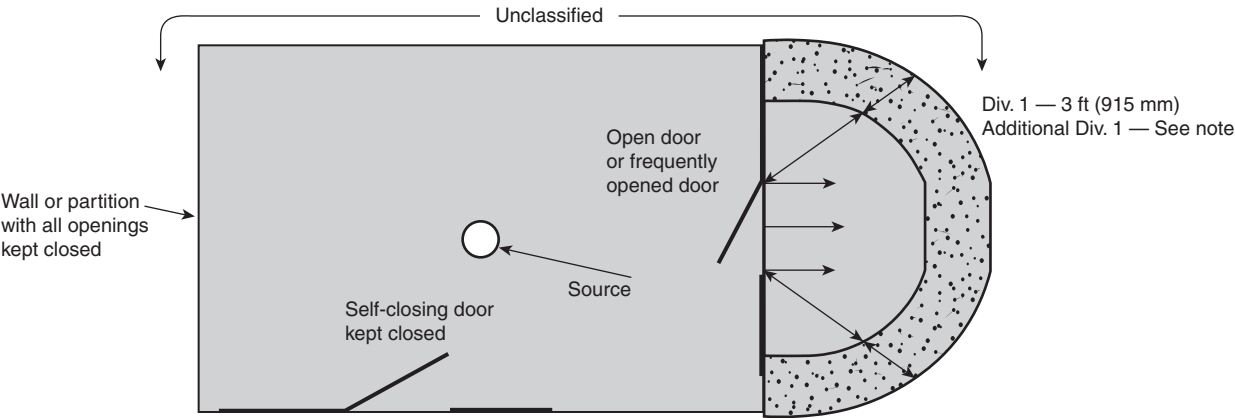
Δ FIGURE 6.10(c) Group F or Group G Dust — Indoor, Unrestricted Area; Operating Equipment Enclosed; Area Classified as a Class II, Division 2 Location.



Δ FIGURE 6.10(d) Group F or Group G Dust — Indoor, Unrestricted Area; Operating Equipment Enclosed; Area is an Unclassified Location.



Δ FIGURE 6.10(e) Groups E, F, or G Dusts — Storage Area Bags, Drums, or Closed Hoppers.



PLAN VIEW

Note: Group E combustible dusts that could be present in quantities sufficient to be hazardous are considered Class II, Division 1 locations per 500.5(C)(1) of *NFPA 70*.
An Additional Division 1 location can be applied as an extra precaution or as conditions warrant.

Class II, Division 1 Additional Class II, Division 1

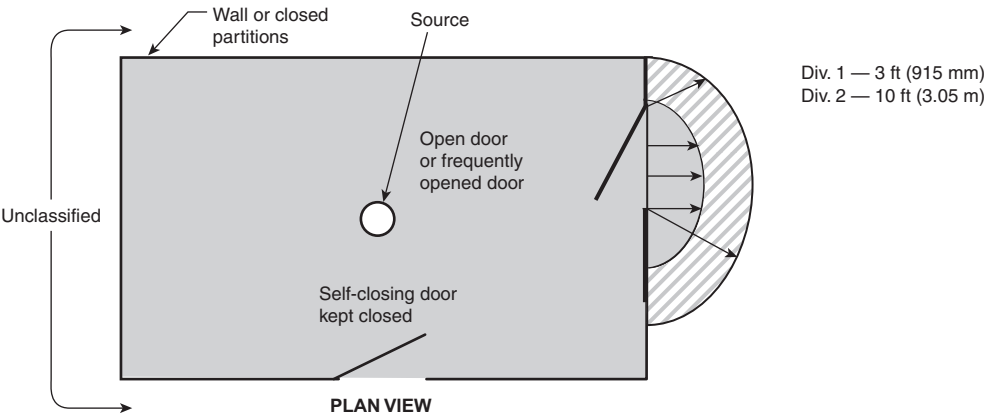
Description of dust condition

Minimize Class II, Division 1 cutoff volume and area.

Description of equipment/area control

Maximize confinement. Maximize dust control.
Maximize housekeeping.
See 6.9.5.

▲ FIGURE 6.10(f) Group E Dust — Indoor, Walled-Off Area; Operating Equipment Enclosed.



PLAN VIEW

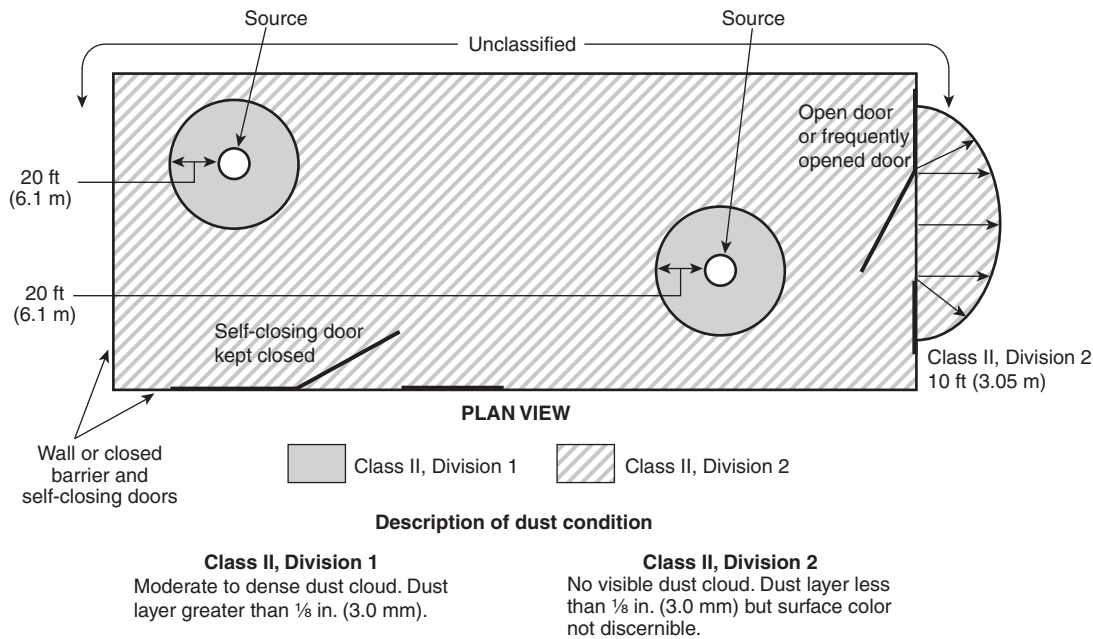
Class II, Division 1 Class II, Division 2

Description of dust condition

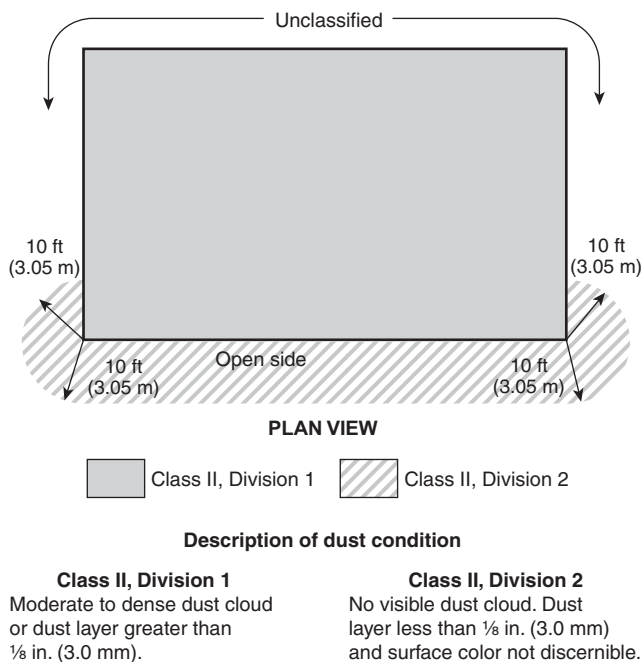
Class II, Division 1
Moderate to dense dust cloud or dust layer greater than 1/8 in. (3.0 mm).

Class II, Division 2
No visible dust cloud. Dust layer less than 1/8 in. (3.0 mm) but surface color not discernible.

▲ FIGURE 6.10(g) Group F or Group G Dust — Indoor, Walled-Off Area; Operating Equipment Open or Semi-Enclosed.



▲ FIGURE 6.10(h) Group F or Group G Dust — Indoor, Walled-Off Area; Multiple Pieces of Operating Equipment.



▲ FIGURE 6.10(i) Group F or Group G Dust — Indoor, Unrestricted Area; Ventilating Bagging Head.

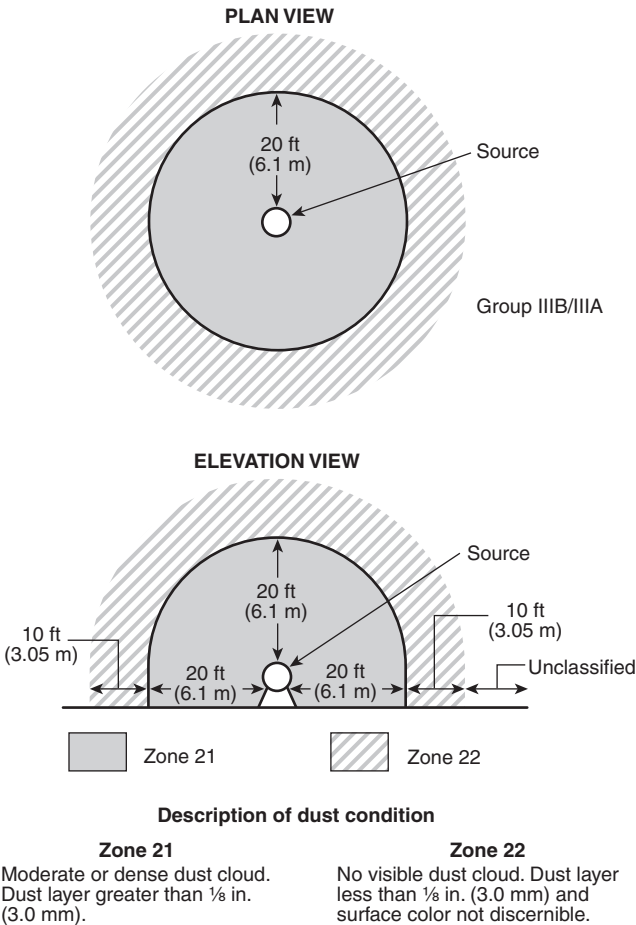


FIGURE 6.10(j) Zone Group IIIB Dust — Indoor, Unrestricted Area; Open or Semi-Enclosed Operating Equipment.

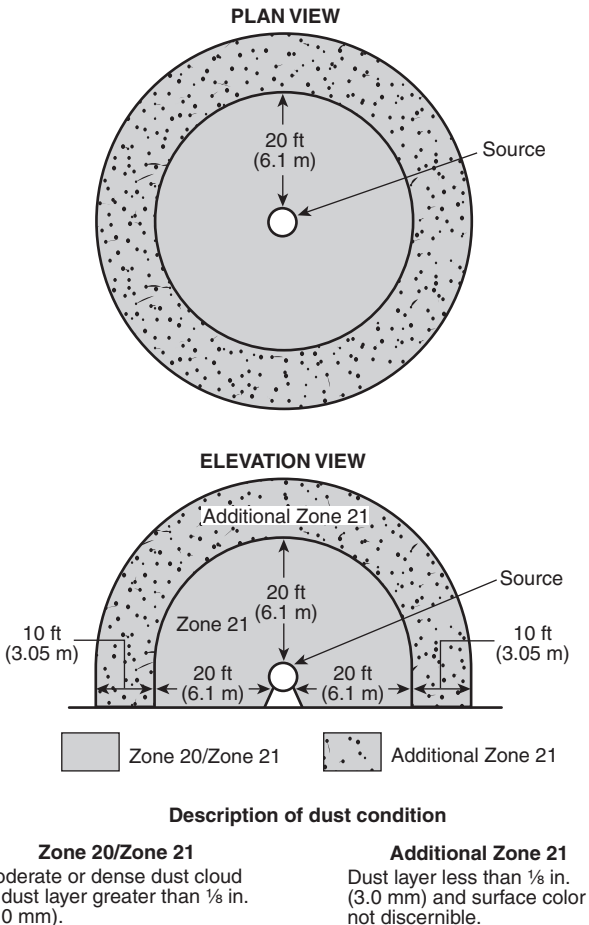


FIGURE 6.10(k) Zone Group IIIC Dust — Indoor, Unrestricted Area; Open or Semi-Enclosed Operating Equipment.

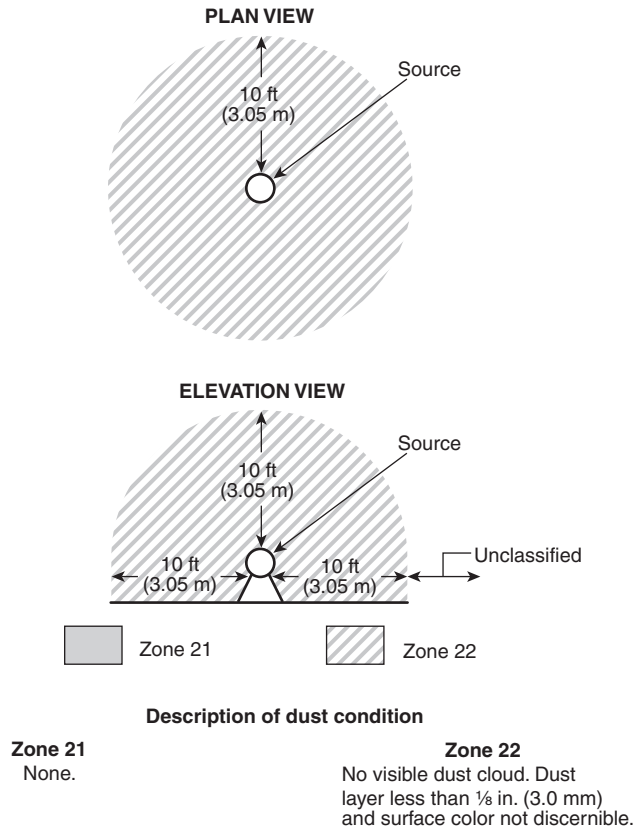


FIGURE 6.10(l) Zone Group IIIB Dust — Indoor, Unrestricted Area; Operating Equipment Enclosed; Area Classified as a Class II, Zone 22 Location.

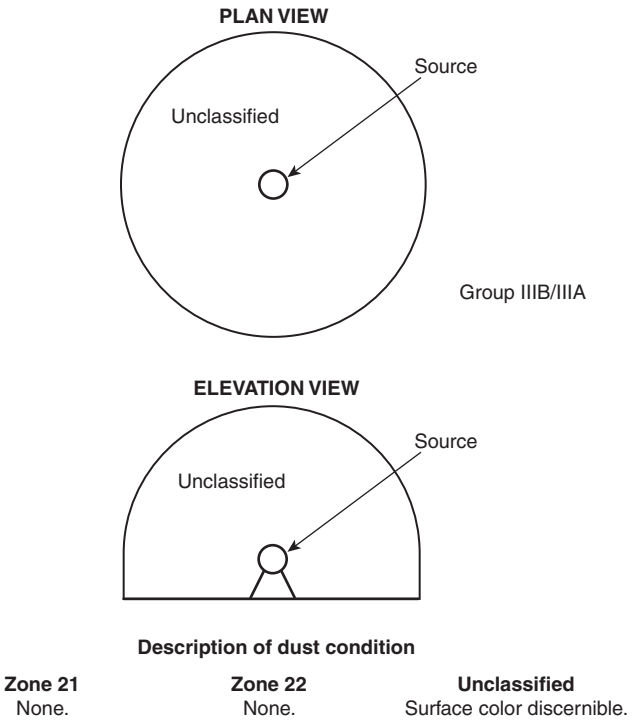


FIGURE 6.10(m) Zone Group IIIB Dust — Indoor, Unrestricted Area; Operating Equipment Enclosed; Area Is an Unclassified Location.

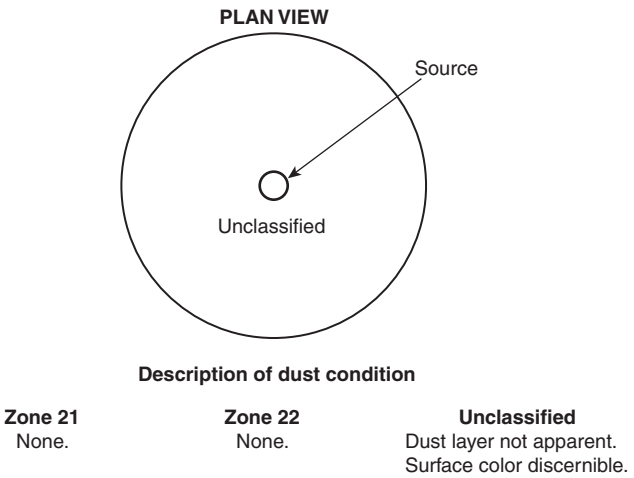
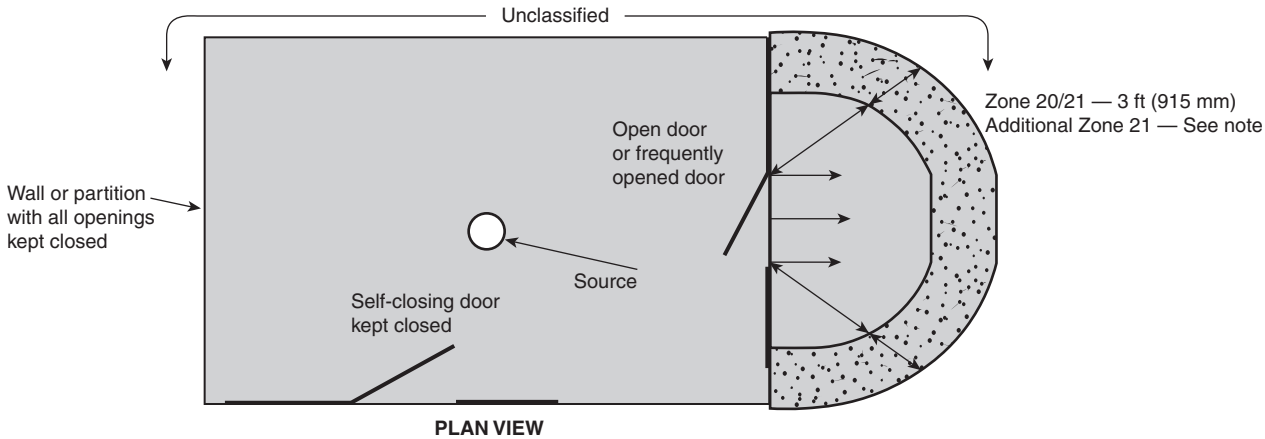


FIGURE 6.10(n) Zone Group IIIC or IIIB Dust — Storage Area; Bags, Drums, or Closed Hoppers.



Note: Combustible metal dusts that could be present in quantities sufficient to be hazardous are considered Class II, Division 1 locations per 500.5(C)(1) of *NFPA 70* and the *NEC* defines Group IIIC combustible dusts as combustible metal dusts. These are Zone 20/21 locations. An Additional Zone 21 can be applied to Group IIIC combustible metal dust either as an extra precaution or as conditions warrant.



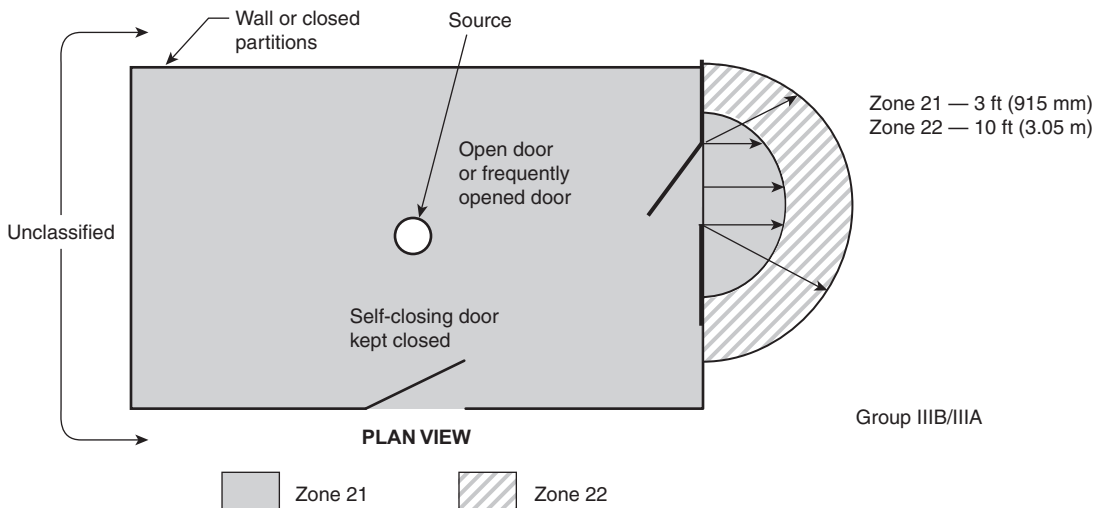
Description of dust condition

Minimize Zone 20/21 cutoff volume and area.

Description of equipment/area control

Maximize confinement.
Maximize dust control.
Maximize housekeeping.
See 6.9.5.

▲ FIGURE 6.10(o) Zone Group IIIC Dust — Indoor, Walled-Off Area; Operating Equipment Enclosed.



Description of dust condition

Zone 21

Moderate to dense dust cloud or dust layer greater than 1/8 in. (3.0 mm).

Zone 22

No visible dust cloud. Dust layer less than 1/8 in. (3.0 mm) but surface color not discernible.

FIGURE 6.10(p) Zone Group IIIB Dust — Indoor, Walled-Off Area; Operating Equipment Open or Semi-Enclosed.

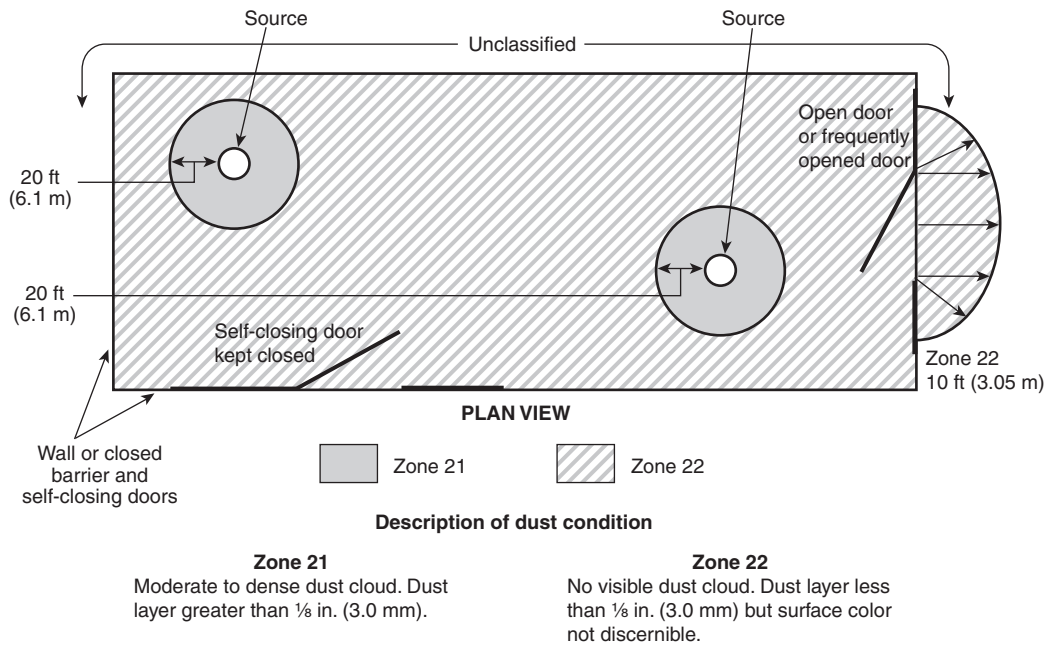


FIGURE 6.10(q) Zone Group IIIB Dust — Indoor, Walled-Off Area; Multiple Pieces of Operating Equipment.

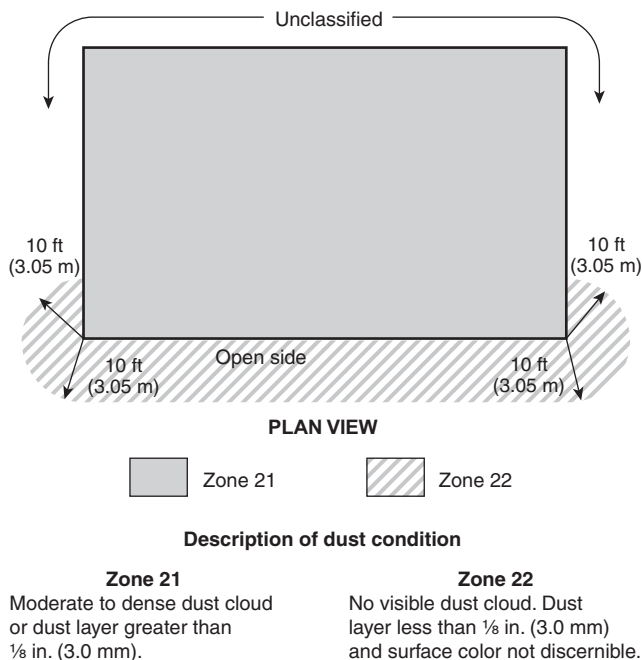


FIGURE 6.10(r) Zone Group IIIB Dust — Indoor, Unrestricted Area; Ventilated Bagging Head.