NFPA® 499

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

2008 Edition

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

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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 December 11, 2007, with an effective date of December 31, 2007, and supersedes all previous editions.

This edition of NFPA 499 was approved as an American National Standard on December 31, 2007.

Origin and Development of NFPA 499

The Technical Committee on Electrical Equipment in Chemical Atmospheres began the development of NFPA 497B in 1989. The Technical Committee based the diagrams in this document on various NFPA codes and standards and on the accepted practices of the chemical process industries. This was the first edition of this recommended practice, and it was adopted by the NFPA membership at the 1990 November Technical Meeting.

In 1993, the Technical Committee on Electrical Equipment in Chemical Atmospheres 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. The table information on dusts was expanded to include CAS numbers for clarity and user-friendliness.

In 2001 the Technical Committee on Electrical Equipment in Chemical Atmospheres entered NFPA 499 into the November 2003 revisions cycle. The 2004 edition was significantly revised and reorganized for conformance with the 2003 *Manual of Style for NFPA Technical Committee Documents*. Those organizational and editorial changes enhanced the usability of this recommended practice. In addition, editorial changes were made to the text to harmonize with the requirements of NFPA 70, *National Electrical Code*.

The 2008 edition is the culmination of a revision cycle that began with the document being entered into cycle in January 2006. NFPA 499 has a close relationship to the electrical installation requirements for hazardous (classified) locations contained in the NFPA 70, *National Electrical Code*. To ensure correlation with revisions occurring in the 2008 NEC, the Technical Committee on Electrical Equipment in Chemical Atmospheres requested and was granted permission by the NFPA Standards Council to enter into a three-year (Fall 2007) revision cycle. Significant revisions to the 2008 edition include: (1) changes to the scope to specify that explosives, pyrotechnics, and blasting agents have unique hazards that are not addressed by the recommendations of the document, and (2) revisions to Table 4.5.2 on composition and ignition temperature of combustible materials covered in this table for correlation with information contained in other industry documents.

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NOTE: Membership on a committee shall not in and of itself constitute an endorsement of the Association or any document developed by the committee on which the member serves.

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

Changes other than editorial are indicated by a vertical rule beside the paragraph, table, or figure in which the change occurred. These rules are included as an aid to the user in identifying changes from the previous edition. Where one or more complete paragraphs have been deleted, the deletion is indicated by a bullet (•) between the paragraphs that remain.

A reference in brackets [ ] following a section or paragraph indicates material that has been extracted from another NFPA document. As an aid to the user, the complete title and edition of the source documents for extracts in the recommendations sections of this document are given in Chapter 2 and those for extracts in the informational sections are given in Annex B. Editorial changes to extracted material consist of revising references to an appropriate division in this document or the inclusion of the document number with the division number when the reference is to the original document. Requests for interpretations or revisions of extracted text should be sent to the technical committee responsible for the source document.

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

Chapter 1 Administration

1.1 Scope.

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

1.1.2 This recommended practice provides information on specific combustible dusts whose relevant combustion properties have been sufficiently identified to allow their classification into the groups established by NFPA 70, *National Electrical Code* (NEC), for proper selection of electrical equipment in hazardous (classified) locations. The tables of selected combustible materials contained in this document are not intended to be all-inclusive.

1.1.3 This recommended practice also applies to chemical process areas. As used in this document, a chemical process area could be a chemical process plant, or it could be a part of such a plant. A chemical process area could be 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.

1.1.4 This recommended practice does not apply to agricultural grain-handling facilities except where powdered grain is used in a chemical reaction or mixture.

1.1.5 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.

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

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 Information is provided on specific combustible dusts whose relevant properties determine their classification into groups. This will assist in the selection of special electrical equipment for hazardous (classified) locations where such electrical equipment is required.

1.2.3 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.

1.2.4 This recommended practice is based on the criteria established by Articles 500 and 502 of the NEC. Once an area is properly classified, the NEC specifies the type of equipment and the wiring methods that shall be permitted to be used.

1.3 Relationship to NFPA Codes and Standards. This recommended practice is not intended to supersede or conflict with the following NFPA standards:

(1) NFPA 36, *Standard for Solvent Extraction Plants*, 2004 edition.
(2) NFPA 61, *Standard for the Prevention of Fires and Dust Explosions in Agricultural and Food Processing Facilities*, 2008 edition.
(3) NFPA 68, *Standard on Explosion Protection by Deflagration Venting*, 2007 edition.
(4) NFPA 69, *Standard on Explosion Prevention Systems*, 2008 edition.
(5) NFPA 484, *Standard for Combustible Metals*, 2006 edition.
(6) NFPA 654, *Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids*, 2006 edition.
(7) NFPA 655, *Standard for Prevention of Sulfur Fires and Explosions*, 2007 edition.
(8) NFPA 664, *Standard for the Prevention of Fires and Explosions in Wood Processing and Woodworking Facilities*, 2007 edition.

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,* 2004 edition.

NFPA 61, *Standard for the Prevention of Fires and Dust Explosions in Agricultural and Food Processing Facilities,* 2008 edition.

NFPA 68, *Standard on Explosion Protection by Deflagration Venting,* 2007 edition.

NFPA 69, *Standard on Explosion Prevention Systems,* 2008 edition.

NFPA 70™, *National Electrical Code*®, 2008 edition.

NFPA 484, *Standard for Combustible Metals,* 2006 edition.

NFPA 654, *Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids,* 2006 edition.

NFPA 655, *Standard for Prevention of Sulfur Fires and Explosions,* 2007 edition.

NFPA 664, *Standard for the Prevention of Fires and Explosions in Wood Processing and Woodworking Facilities,* 2007 edition.

2.3 Other Publications.

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

ASTM D 3175, *Standard Test Method for Volatile Matter in the Analysis Sample of Coal and Coke*, 1989.

2.3.2 Other Publications.

Merriam-Webster's Collegiate Dictionary, 11th edition, Merriam-Webster, Inc., Springfield, MA, 2003.

2.4 References for Extracts in Recommendations Sections.

NFPA 70™, *National Electrical Code*®, 2008 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. A document that is 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. Any finely divided solid material that is 420 microns or smaller in diameter (material passing a U.S. No. 40 Standard Sieve) and presents a fire or explosion hazard when dispersed and ignited in air.

3.3.4 Combustible Dust, Class II. Class II combustible dusts are divided into Groups E, F, and G.

3.3.4.1 ***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.

3.3.4.2 ***Group F.*** Atmospheres containing combustible carbonaceous dusts that have more than 8 percent total entrapped volatiles (see ASTM D 3175, *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. Coal, carbon black, charcoal, and coke dusts are examples of carbonaceous dusts.

3.3.4.3 ***Group G.*** Atmospheres containing other combustible dusts, including flour, grain, wood flour, plastic, and chemicals.

3.3.5 Combustible Material. A generic term used to describe either a mixture of dust in air, or a hybrid mixture, that may burn, flame, or explode.

3.3.6* Explosion Severity. A measure of the damage potential of the energy released by a dust explosion.

3.3.7 Hybrid Mixture. A mixture of a dust with one or more flammable gases or vapors.

3.3.8 Ignitible Mixture. A combustible material that is within its flammable range.

3.3.9* Ignition Sensitivity. A measure of the ease by which a cloud of combustible dust could be ignited.

Chapter 4 Combustible Dusts

4.1 ***National Electrical Code*** **Criteria.**

4.1.1 Article 500 of the NEC classifies any location in which a combustible material is or can be present in the atmosphere in sufficient concentrations to produce an ignitible mixture.

4.1.2* In a Class II hazardous (classified) location, the combustible material present is a combustible dust.

4.1.3 Class II is further subdivided into either Class II, Division 1 or Class II, Division 2 as follows.

4.1.3.1 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 ignitible mixtures, or
(2) Where mechanical failure or abnormal operation of machinery or equipment might cause such explosive or ignitible mixtures to be produced, and might also provide a source of ignition through simultaneous failure of electric equipment, through operation of protection devices, or from other causes, or
(3) In which combustible dusts of an electrically conductive nature may be present in hazardous quantities. [**70:**500.5(C)(1)]

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

(1) Where combustible dust is not normally in the air in quantities sufficient to produce explosive or ignitible mixtures, and dust accumulations are normally insufficient to interfere with the normal operation of electrical equipment or other apparatus, but combustible dust may be in suspension in the air as a result of infrequent malfunctioning of handling or processing equipment and
(2) Where combustible dust accumulations on, in, or in the vicinity of the electrical equipment may be sufficient to interfere with the safe dissipation of heat from electrical equipment or may be ignitible by abnormal operation or failure of electrical equipment. [**70:**500.5(C)(2)]

4.1.4 The intent of Article 500 of the NEC is to prevent the use of electrical equipment and systems in hazardous (classified) locations that would ignite an ignitible dust cloud or layer.

4.1.5 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.

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

4.1.5.2 Other dusttight equipment enclosures, as specified in Article 502 of the NEC, are permitted in Division 2 locations.

4.1.5.3 Electrical equipment protected by pressurizing and intrinsically safe electrical equipment are applicable to both Division 1 and Division 2 locations.

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

4.1.6 Electrical equipment in Division 1 locations is enclosed in a manner that will exclude ignitible 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.

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

4.1.7.1 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 ignitible mixture are extremely remote.

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

4.1.7.3 Electrical installations in Division 2 locations could be designed with dusttight enclosures or other equipment enclosures as specified in Article 502 of the NEC.

4.1.8 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.

4.1.9 Where Group E dusts are present in hazardous quantities, there are only Division 1 locations. The NEC does not recognize any Division 2 locations for such dusts.

4.1.10 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.

4.1.11 For the purpose of this recommended practice, locations not classified as Division 1 or Division 2 are "unclassified" locations.

4.2 Behavior of Combustible Dusts.

4.2.1 Dispersion and Explosion.

4.2.1.1 Dust discharged or leaking from equipment into the atmosphere is acted on by gravity and will settle relatively quickly, depending on the size of particles, the internal pressure propelling the particles out of the equipment, and any air currents in the vicinity.

4.2.1.1.1 The result is a layer of dust that settles on horizontal surfaces below the leak opening in a radial or elliptical manner, depending on the location of the opening on the equipment.

4.2.1.1.2 The depth of the layer will be greatest under and close to the source and will taper off to the outside of the circle or ellipse.

4.2.1.1.3 The greater the height of the dust source above the surface, the greater the area covered.

4.2.1.1.4 The internal pressure in the equipment will likewise increase the area covered.

4.2.1.1.5 The size of the leak opening and the elapsed time of emission also affect the quantity of dust on the surface.

4.2.1.1.6 Some dusts have particles that are extremely fine and light (i.e., have a low specific particle density). Such particles could behave more like vapors than like dusts and could remain in suspension for long periods. These particles could travel far from the emitting source and collect on surfaces above the source.

4.2.1.1.7 Although horizontal surfaces accumulate the largest quantities of dust, vertical surfaces could in some instances also accumulate significant quantities.

4.2.1.2 Although a dust cloud will ignite and explode readily in the presence of an open ignition source, dust layers, if undisturbed and not in direct contact with the ignition source, will not explode. However, if a small amount of dust is dispersed in the air at the ignition source, a small explosion will occur. The pressure wave from this explosion blows the dust layer into the air, and a larger explosion then takes place. It is often this secondary explosion that does the most damage.

4.2.2* Hybrid Mixtures. The presence of the flammable gas or vapor, even at concentrations less than their lower flammable limit (LFL), will not only 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 where 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) and the Class II (combustible dust).

4.3* Conditions Necessary for Ignition of a Combustible Dust.

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

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

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

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

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

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

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

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

4.3.2.1 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.

4.3.2.2 For this reason, good housekeeping is vitally important in all areas where dust is handled, and is assumed throughout this recommended practice.

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

4.3.3.1 The classification depends both on the presence of dust clouds and on the presence of hazardous accumulations of dust in layer form.

4.3.3.2 As specified in 4.1.3.1, the presence of a combustible dust cloud under normal conditions of operation, or due to frequent repair or maintenance, should be classified as Division 1.

4.3.3.3 Abnormal operation of machinery and equipment, which could simultaneously produce a dust cloud or suspension and a source of ignition, also should be classified as Division 1.

4.3.3.4 In other words, if a dust cloud is present at any time, it is assumed to be ignitible, and all that is necessary for electrical ignition is failure of the electrical system.

4.3.3.5 If dust clouds or hazardous dust accumulations are present 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 Division 2.

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

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

4.4 Dusts with Additional Hazards.

4.4.1 Conductive Dusts. Group E dusts could cause a short in the electrical equipment when exposed to sufficiently high voltages.

4.4.2 Group E dusts are sensitive to a phenomenon whereby an electric current finds the path of least resistance through a dust layer, heating up the dust particles in its path and thus providing a source of ignition. The resulting electric arc could ignite a dust layer or dust cloud.

4.4.3 Magnesium or Aluminum Dust. Dusts containing magnesium or aluminum are particularly hazardous, and the use of extreme precaution will be necessary to avoid ignition and explosion.

4.4.4 Low-Ignition Temperature Dusts. Zirconium, thorium, and uranium dusts have extremely low ignition temperatures [as low as 20°C (68°F)] and extremely low minimum ignition energies.

4.5 Classification of Combustible Dusts.

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

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

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

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

4.6 Ignition of Dust Clouds.

4.6.1 The electrical equipment enclosure prevents the dust cloud from being ignited by arcing and sparking parts, or other ignition sources within the enclosure.

4.6.2 The dust cloud could be ignited by hot surface temperatures.

4.6.3 Some dusts that are not normally combustible could form explosive dust clouds when mixed with a flammable gas. See 4.2.2 for discussion on hybrid mixture.

4.7 Ignition of Dust Layers.

4.7.1 The ignition temperature of a dust layer is a function of the type of dust and its physical and chemical properties and is often less than the cloud ignition temperature. The ignition temperature shown in Table 4.5.2 is the lower of the two.

Table 4.5.2 Selected Combustible Materials

Chemical Name	CAS No.	NEC Group	Code	Layer or Cloud Ignition Temp. (°C)
Acetal, Linear		G	NL	440
Acetoacet-p-phenetidide	122-82-7	G	NL	560
Acetoacetanilide	102-01-2	G	M	440
Acetylamino-t-nitrothiazole		G		450
Acrylamide Polymer		G		240
Acrylonitrile Polymer		G		460
Acrylonitrile-Vinyl Chloride-Vinylidenechloride copolymer (70-20-10)		G		210
Acrylonitrile-Vinyl Pyridine Copolymer		G		240
Adipic Acid	124-04-9	G	M	550
Alfalfa Meal		G		200
Alkyl Ketone Dimer Sizing Compound		G		160
Allyl Alcohol Derivative (CR-39)		G	NL	500
Almond Shell		G		200
Aluminum, A422 Flake	7429-90-5	E		320
Aluminum, Atomized Collector Fines		E	CL	550
Aluminum—cobalt alloy (60-40)		E		570
Aluminum—copper alloy (50-50)		E		830
Aluminum—lithium alloy (15% Li)		E		400
Aluminum—magnesium alloy (Dowmetal)		E	CL	430
Aluminum—nickel alloy (58-42)		E		540
Aluminum—silicon alloy (12% Si)		E	NL	670
Amino-5-nitrothiazole	121-66-4	G		460
Anthranilic Acid	118-92-3	G	M	580
Apricot Pit		G		230
Aryl-nitrosomethylamide		G	NL	490
Asphalt	8052-42-4	F		510
Aspirin [acetol (2)]	50-78-2	G	M	660
Azelaic Acid	109-31-9	G	M	610
Azo-bis-butyronitrile	78-67-1	G		350
Benzethonium Chloride		G	CL	380
Benzoic Acid	65-85-0	G	M	440
Benzotriazole	95-14-7	G	M	440
Beta-naphthalene-axo-dimethylaniline		G		175
Bis(2-hydroxy-5-chlorophenyl) Methane	97-23-4	G	NL	570
Bisphenol-A	80-05-7	G	M	570
Boron, Commercial Amorphous (85% B)	7440-42-8	E		400
Calcium Silicide		E		540
Carbon Black (More Than 8% Total Entrapped Volatiles)		F		
Carboxymethyl Cellulose	9000-11-7	G		290
Carboxypolymethylene		G	NL	520
Cashew Oil, Phenolic, Hard		G		180
Cellulose		G		260
Cellulose Acetate		G		340
Cellulose Acetate Butyrate		G	NL	370
Cellulose Triacetate		G	NL	430
Charcoal (Activated)	64365-11-3	F		180
Charcoal (More Than 8% Total Entrapped Volatiles)		F		
Cherry Pit		G		220
Chlorinated Phenol		G	NL	570
Chlorinated Polyether Alcohol		G		460
Chloroacetoacetanilide	101-92-8	G	M	640
Chromium (97%) Electrolytic, Milled	7440-47-3	E		400
Cinnamon		G		230
Citrus Peel		G		270
Coal, Kentucky Bituminous		F		180
Coal, Pittsburgh Experimental		F		170
Coal, Wyoming		F		180
Cocoa Bean Shell		G		370
Cocoa, Natural, 19% Fat		G		240

Table 4.5.2 ***Continued***

Chemical Name	CAS No.	NEC Group	Code	Layer or Cloud Ignition Temp. (°C)
Coconut Shell		G		220
Coke (More Than 8% Total Entrapped Volatiles)		F		
Cork		G		210
Corn		G		250
Corn Dextrine		G		370
Corncob Grit		G		240
Cornstarch, Commercial		G		330
Cornstarch, Modified		G		200
Cottonseed Meal		G		200
Coumarone-Indene, Hard		G	NL	520
Crag No. 974	533-74-4	G	CL	310
Cube Root, South America	83-79-4	G		230
Di-alphacumyl Peroxide, 40-60 on CA	80-43-3	G		180
Diallyl Phthalate	131-17-9	G	M	480
Dicyclopentadiene Dioxide		G	NL	420
Dieldrin (20%)	60-57-1	G	NL	550
Dihydroacetic Acid		G	NL	430
Dimethyl Isophthalate	1459-93-4	G	M	580
Dimethyl Terephthalate	120-61-6	G	M	570
Dinitro-o-toluamide	148-01-6	G	NL	500
Dinitrobenzoic Acid		G	NL	460
Diphenyl	92-52-4	G	M	630
Ditertiary-butyl-paracresol	128-37-0	G	NL	420
Dithane m-45	8018-01-7	G		180
Epoxy		G	NL	540
Epoxy-bisphenol A		G	NL	510
Ethyl Cellulose		G	CL	320
Ethyl Hydroxyethyl Cellulose		G	NL	390
Ethylene Oxide Polymer		G	NL	350
Ethylene-maleic Anhydride Copolymer		G	NL	540
Ferbam™	14484-64-1	G		150
Ferromanganese, Medium Carbon	12604-53-4	E		290
Ferrosilicon (88% Si, 9% Fe)	8049-17-0	E		800
Ferrotitanium (19% Ti, 74.1% Fe, 0.06% C)		E	CL	380
Flax Shive		G		230
Fumaric Acid	110-17-8	G	M	520
Garlic, Dehydrated		G	NL	360
Gilsonite	12002-43-6	F		500
Green Base Harmon Dye		G		175
Guar Seed		G	NL	500
Gulasonic Acid, Diacetone		G	NL	420
Gum, Arabic		G		260
Gum, Karaya		G		240
Gum, Manila		G	CL	360
Gum, Tragacanth	9000-65-1	G		260
Hemp Hurd		G		220
Hexamethylene Tetramine	100-97-0	G	S	410
Hydroxyethyl Cellulose		G	NL	410
Iron, 98% H_2 Reduced		E		290
Iron, 99% Carbonyl	13463-40-6	E		310
Isotoic Anhydride		G	NL	700
L-sorbose		G	M	370
Lignin, Hydrolized, Wood-type, Fine		G	NL	450
Lignite, California		F		180
Lycopodium		G		190
Malt Barley		G		250
Manganese	7439-96-5	E		240
Magnesium, Grade B, Milled		E		430
Manganese Vancide		G		120
Mannitol	69-65-8	G	M	460

(continues)

Table 4.5.2 ***Continued***

Chemical Name	CAS No.	NEC Group	Code	Layer or Cloud Ignition Temp. (°C)
Methacrylic Acid Polymer		G		290
Methionine (l-methionine)	63-68-3	G		360
Methyl Cellulose		G		340
Methyl Methacrylate Polymer	9011-14-7	G	NL	440
Methyl Methacrylate-ethyl Acrylate		G	NL	440
Methyl Methacrylate-styrene-butadiene		G	NL	480
Milk, Skimmed		G		200
N,N-Dimethylthio-formamide		G		230
Nitropyridone	100703-82-0	G	M	430
Nitrosamine		G	NL	270
Nylon Polymer	63428-84-2	G		430
Para-oxy-benzaldehyde	123-08-0	G	CL	380
Paraphenylene Diamine	106-50-3	G	M	620
Paratertiary Butyl Benzoic Acid	98-73-7	G	M	560
Pea Flour		G		260
Peach Pit Shell		G		210
Peanut Hull		G		210
Peat, Sphagnum	94114-14-4	G		240
Pecan Nut Shell	8002-03-7	G		210
Pectin	5328-37-0	G		200
Pentaerythritol	115-77-5	G	M	400
Petrin Acrylate Monomer	7659-34-9	G	NL	220
Petroleum Coke (More Than 8% Total Entrapped Volatiles)		F		
Petroleum Resin	64742-16-1	G		500
Phenol Formaldehyde	9003-35-4	G	NL	580
Phenol Formaldehyde, Polyalkylene-p	9003-35-4	G		290
Phenol Furfural	26338-61-4	G		310
Phenylbetanaphthylamine	135-88-6	G	NL	680
Phthalic Anydride	85-44-9	G	M	650
Phthalimide	85-41-6	G	M	630
Pitch, Coal Tar	65996-93-2	F	NL	710
Pitch, Petroleum	68187-58-6	F	NL	630
Polycarbonate		G	NL	710
Polyethylene, High Pressure Process	9002-88-4	G		380
Polyethylene, Low Pressure Process	9002-88-4	G	NL	420
Polyethylene Terephthalate	25038-59-9	G	NL	500
Polyethylene Wax	68441-04-8	G	NL	400
Polypropylene (no antioxidant)	9003-07-0	G	NL	420
Polystyrene Latex	9003-53-6	G		500
Polystyrene Molding Compound	9003-53-6	G	NL	560
Polyurethane Foam, Fire Retardant	9009-54-5	G		390
Polyurethane Foam, No Fire Retardant	9009-54-5	G		440
Polyvinyl Acetate	9003-20-7	G	NL	550
Polyvinyl Acetate/Alcohol	9002-89-5	G		440
Polyvinyl Butyral	63148-65-2	G		390
Polyvinyl Chloride-dioctyl Phthalate		G	NL	320
Potato Starch, Dextrinated	9005-25-8	G	NL	440
Pyrethrum	8003-34-7	G		210
Rayon (Viscose) Flock	61788-77-0	G		250
Red Dye Intermediate		G		175
Rice		G		220
Rice Bran		G	NL	490
Rice Hull		G		220
Rosin, DK	8050-09-7	G	NL	390
Rubber, Crude, Hard	9006-04-6	G	NL	350
Rubber, Synthetic, Hard (33% S)	64706-29-2	G	NL	320
Safflower Meal		G		210
Salicylanilide	87-17-2	G	M	610
Sevin	63-25-2	G		140

Table 4.5.2 ***Continued***

Chemical Name	CAS No.	NEC Group	Code	Layer or Cloud Ignition Temp. (°C)
Shale, Oil	68308-34-9	F		
Shellac	9000-59-3	G	NL	400
Sodium Resinate	61790-51-0	G		220
Sorbic Acid (Copper Sorbate or Potash)	110-44-1	G		460
Soy Flour	68513-95-1	G		190
Soy Protein	9010-10-0	G		260
Stearic Acid, Aluminum Salt	637-12-7	G		300
Stearic Acid, Zinc Salt	557-05-1	G	M	510
Styrene Modified Polyester-Glass Fiber	100-42-5	G		360
Styrene-acrylonitrile (70-30)	9003-54-7	G	NL	500
Styrene-butadiene Latex (>75% styrene)	903-55-8	G	NL	440
Styrene-maleic Anhydride Copolymer	9011-13-6	G	CL	470
Sucrose	57-50-1	G	CL	350
Sugar, Powdered	57-50-1	G	CL	370
Sulfur	7704-34-9	G		220
Tantalum	7440-25-7	E		300
Terephthalic Acid	100-21-0	G	NL	680
Thorium (contains 1.2% O)	7440-29-1	E	CL	270
Tin, 96%, Atomized (2% Pb)	7440-31-5	E		430
Titanium, 99% Ti	7440-32-6	E	CL	330
Titanium Hydride (95% Ti, 3.8% H)	7704-98-5	E	CL	480
Trithiobisdimethylthio-formamide		G		230
Tung, Kernels, Oil-free	8001-20-5	G		240
Urea Formaldehyde Molding Compound	9011-05-6	G	NL	460
Urea Formaldehyde-phenol Formaldehyde	25104-55-6	G		240
Vanadium, 86.4%	7440-62-2	E		490
Vinyl Chloride-acrylonitrile Copolymer	9003-00-3	G		470
Vinyl Toluene-acrylonitrile Butadiene	76404-69-8	G	NL	530
Violet 200 Dye		G		175
Vitamin B1, Mononitrate	59-43-8	G	NL	360
Vitamin C	50-81-7	G		280
Walnut Shell, Black		G		220
Wheat		G		220
Wheat Flour	130498-22-5	G		360
Wheat Gluten, Gum	100684-25-1	G	NL	520
Wheat Starch		G	NL	380
Wheat Straw		G		220
Wood Flour		G		260
Woodbark, Ground		G		250
Yeast, Torula	68602-94-8	G		260
Zirconium Hydride	7704-99-6	E		270
Zirconium (contains 0.3% O)	7440-67-7	E	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. Since 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 sublimes before it ignites; the cloud ignition temperature is shown.
2. Certain metal dusts may have characteristics that require safeguards beyond those required for atmospheres containing the dusts of aluminum, magnesium, and their commercial alloys. For example, zirconium and thorium dusts may ignite spontaneously in air, especially at elevated temperatures.
3. 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 4.5.3 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-alphacumyl Peroxide, 40-60 on CA
83-79-4	Cube Root, South America
85-41-6	Phthalimide
85-44-9	Phthalic Anydride
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-phenetidide
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
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	Ferbam™
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

4.7.2 The ignition temperature of a layer of organic dust on heat-producing equipment can decrease over time if the dust dehydrates or carbonizes. For this reason, the heat-producing equipment is not permitted to exceed the lower of either the ignition temperature or 165°C (329°F).

4.7.3 Some dusts in layers could melt before reaching their layer ignition temperatures. This melted material could then act more like a combustible liquid than a dust.

4.7.4 Other dusts, such as some polymers, degrade to a lower molecular weight material or to the monomer itself. This dust could act more like a flammable liquid than a dust.

4.7.5 Materials such as unplasticized polyvinyl chloride, sulfur, and zinc stearate melt, but cause only maintenance problems.

4.7.6 An ignited dust layer introduces an open-flame ignition source that can ignite a dust cloud in the vicinity and also can stir up the dust layer, creating a dust cloud.

Chapter 5 Classification of Class II (Combustible Dust) Locations

5.1 General.

5.1.1 The decision to classify an area as hazardous should be based on the probability that a combustible mixture could be present.

5.1.2 Once it is decided that an area should be classified, the next step should be to determine the degree of hazard: Is the area Division 1 or Division 2?

5.2 Division 1 Classified Locations.

5.2.1 Where a dust cloud is likely to be present under normal conditions, the location should be classified as Division 1.

5.2.2* Where a dust layer greater than ⅛ in. (3.0 mm) thick is present under normal conditions, the location should be classified as Division 1.

5.2.3 "Normal" does not necessarily mean the situation that prevails when everything is working properly.

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

5.2.3.2 If quantities of ignitible dust are released as a result of the maintenance, the location is Division 1.

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

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

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

5.3 Division 2 Classified Locations.

5.3.1 The criterion for a Division 2 location is whether the location is likely to have ignitible 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.

5.3.2 As an example, consider the replaced bucket elevator of 5.2.3.1, which releases ignitible dust only under abnormal conditions. In this case there is no Division 1 location because the elevator is normally tight. To release dust, the elevator would have to leak, and that would not be normal.

5.3.3 Chemical process equipment does not fail often. Furthermore, the electrical installation requirement of the NEC for Division 2 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.

5.3.4 The Division 2 classification is applicable to conditions not involving equipment failure. For example, consider a location classified as Division 1 because of normal presence of ignitible dust suspension. Obviously, one side of the Division 1 boundary cannot be normally hazardous and the opposite side never hazardous. Similarly, consider a location classified as 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.

5.3.5 When there is no wall, a surrounding transition Division 2 location separates a Division 1 location from an unclassified location.

5.3.6 Walls are much more important in separating Division 1 locations from Division 2 and unclassified locations in Class II locations than in Class I locations.

5.3.6.1 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 locations and unclassified locations.

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

5.4 Unclassified Locations.

5.4.1 Experience has shown that the release of ignitible 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.5.2.2)*
(6) Where excellent housekeeping prevents the following:
    (a) Visual dust clouds
    (b) Layer accumulations that make surface colors indiscernible *(see A.5.2.2)*

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

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

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

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

5.4.3.3 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.

5.5 Extent of Hazardous (Classified) Locations.

5.5.1 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

5.5.2 The dispersal of dusts and the influence of the factors in 5.5.1 on this dispersal are discussed generally in Sections 4.2 through 4.7. The importance of dust removal and housekeeping are discussed in other paragraphs of this chapter.

5.5.3 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 Division 1 and Division 2 locations.

5.5.4 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.

5.5.5 Where effective walls are not provided, the extent of the Division 1 and Division 2 locations can be estimated as follows:

(1) By visual observation of the existing location using the guidelines of A.5.2.2
(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

5.5.6 Tight equipment, ventilated hoods and pickup points, good maintenance, and good housekeeping practices should limit Division 1 locations to those inside of process enclosures and equipment and 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 Division 2 location surrounding the Division 1 location.

5.5.7 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 Division 1 or Division 2.

5.5.8 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, continue to follow it. Sound engineering judgment and good housekeeping should be used to minimize the extent of hazardous (classified) locations.

5.5.8.1 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, use the concentric volume approach of a Division 1 location surrounded by a larger Division 2 location, as shown in the diagrams.

5.5.8.2 Where it is necessary to have a number of dusty operations located in a building, there could be a multiplicity of Division 1 locations, with intervening Division 2 and unclassified locations.

5.5.9 The quantity of dust released and its distance of travel is 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.

5.6 Discussion of Diagrams and Recommendations.

5.6.1 The series of diagrams in Section 5.8 illustrate how typical dusty areas should be classified and the recommended extent of classification.

5.6.2 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.

5.6.3 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 Division 1 and Division 2 locations can be applied.

5.6.4 These diagrams apply to operating equipment processing dusts when the specific particle density is greater than 40 lb/ft^3 (640.72 kg/m^3). When dusts with a specific particle density less than 40 lb/ft^3 (640.72 kg/m^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.

5.6.5 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.

5.7 Procedure for Classifying Areas. Paragraphs 5.7.1 through 5.7.4 detail the procedure that should be used for each room, section, or area being classified.

5.7.1 Step One — Need for Classification. The area should be classified if a combustible material is processed, handled, or stored there.

5.7.2 Step Two — Gathering Information.

5.7.2.1 Proposed Facility Information. For a proposed facility that exists on drawings only, 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.

5.7.2.2 Existing Facility History. For an existing facility, the individual plant experience is extremely important in classifying 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 ignitible mixture?
(2) Are there dust layers or accumulations on surfaces deeper than ⅛ in. (3.0 mm)?
(3) Are there dust layers or accumulations on surfaces that make the colors of 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 ignitible mixtures?
(7) What equipment is used for dust collection?

5.7.2.3 Material Density. Determine if the specific particle density of the dust is at least 40 lb/ft^3 (640.72 kg/m^3).

5.7.2.4 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.

5.7.2.5 Fire Hazard Properties of Combustible Material. The NEC group and the layer or cloud ignition temperature are shown in Table 4.5.2 for many materials.

5.7.2.5.1 A material could be listed in Table 4.5.2 under a chemical name different than the chemical name used at the facility. Table 4.5.3 is provided to cross-reference the CAS number of the material to the chemical name used in Table 4.5.2.

5.7.2.5.2 Where materials being used are not listed in Table 4.5.2 or in other reputable chemical references, the information needed to classify the area can be obtained by one of the following methods:

(1) Contact the material supplier to determine if the material has been group classified.
(2) Have the material tested to determine if the ignition sensitivity is less than 0.2 and the explosion severity is less than 0.5. Area classification is not considered necessary for dusts that meet both criteria.

5.7.3 Step Three — Selecting the Appropriate Classification Diagram. Select the appropriate diagrams based on the following:

(1) Whether the process equipment is open or enclosed
(2) Whether the dust is Group E, F, or G
(3) Whether the area is for storage

5.7.4 Step Four — 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 5.5 and the diagrams contained in this chapter.

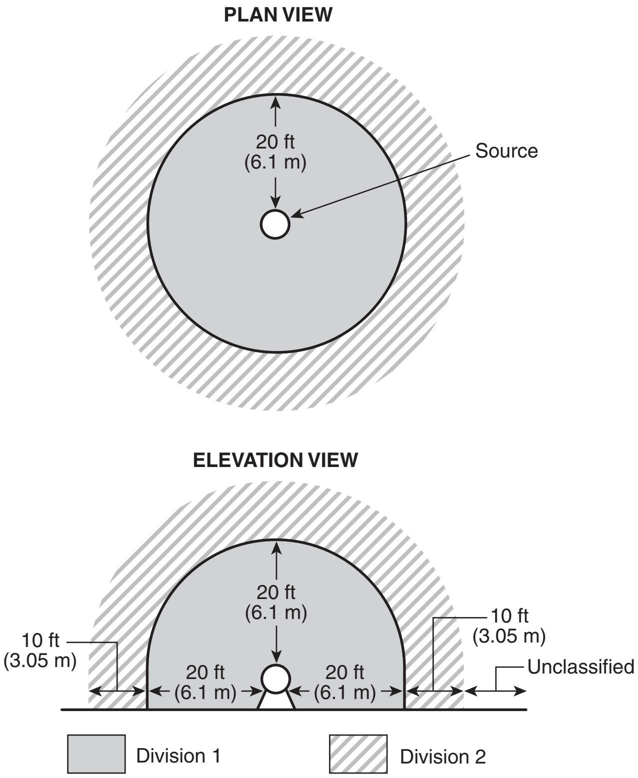
5.7.4.1 Locate the potential sources of leaks on the plan drawing or at the actual location. These sources of leaks could include rotating or reciprocating shafts, doors and covers on process equipment, and so forth.

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

(1) Whether an ignitible 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

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

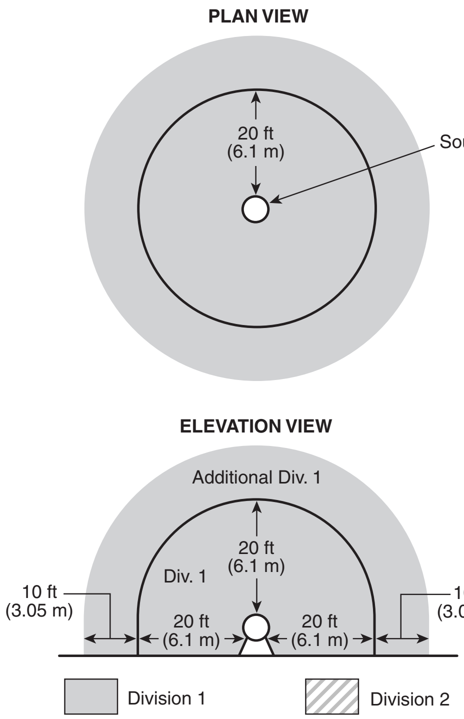
5.8 Classification Diagrams. Classification diagrams are shown in Figure 5.8(a) through Figure 5.8(i). These diagrams assume that the specific particle density is greater than 40 lb/ft^3 (640.72 kg/m^3).



Description of dust condition

Division 1	Division 2
Moderate or dense dust cloud. Dust layer greater than ⅛ in. (3.0 mm).	No visible dust cloud. Dust layer less than ⅛ in. (3.0 mm) and surface color not discernible.

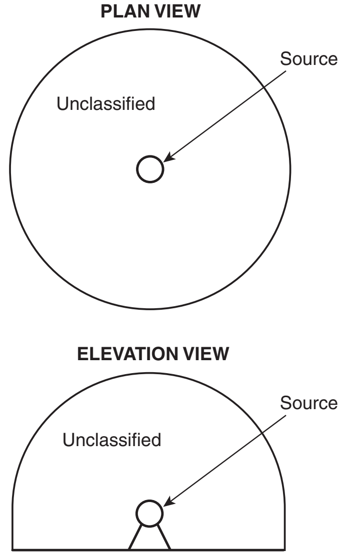
FIGURE 5.8(a) Group F or Group G Dust — Indoor, Unrestricted Area; Open or Semi-Enclosed Operating Equipment.



Description of dust condition

Division 1	Additional Division 1
Moderate or dense dust cloud or dust layer greater than ⅛ in. (3.0 mm).	Dust layer less than ⅛ in. (3.0 mm) and surface color not discernible.

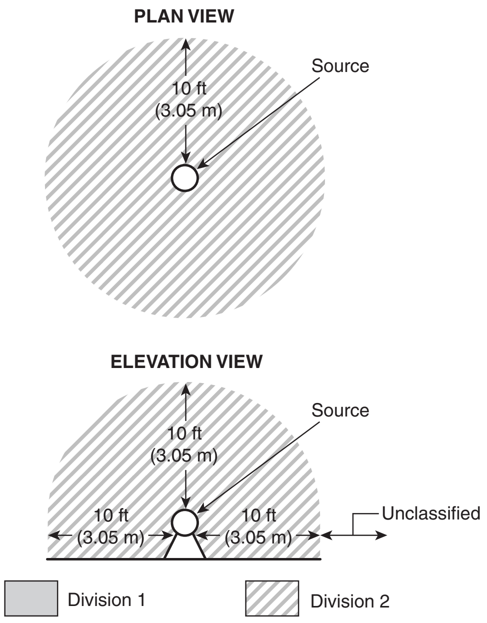
FIGURE 5.8(b) Group E Dust — Indoor, Unrestricted Area; Open or Semi-Enclosed Operating Equipment.



Description of dust condition

Division 1	Division 2	Unclassified
None	None	Surface color discernible.

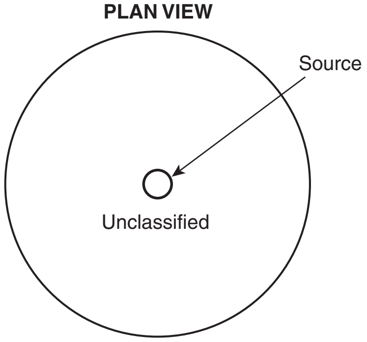
FIGURE 5.8(d) Group F or Group G Dust — Indoor, Unrestricted Area; Operating Equipment Enclosed; Area is an Unclassified Location.



Description of dust condition

Division 1	Division 2
None	No visible dust cloud. Dust layer less than ⅛ in. (3.0 mm) and surface color not discernible.

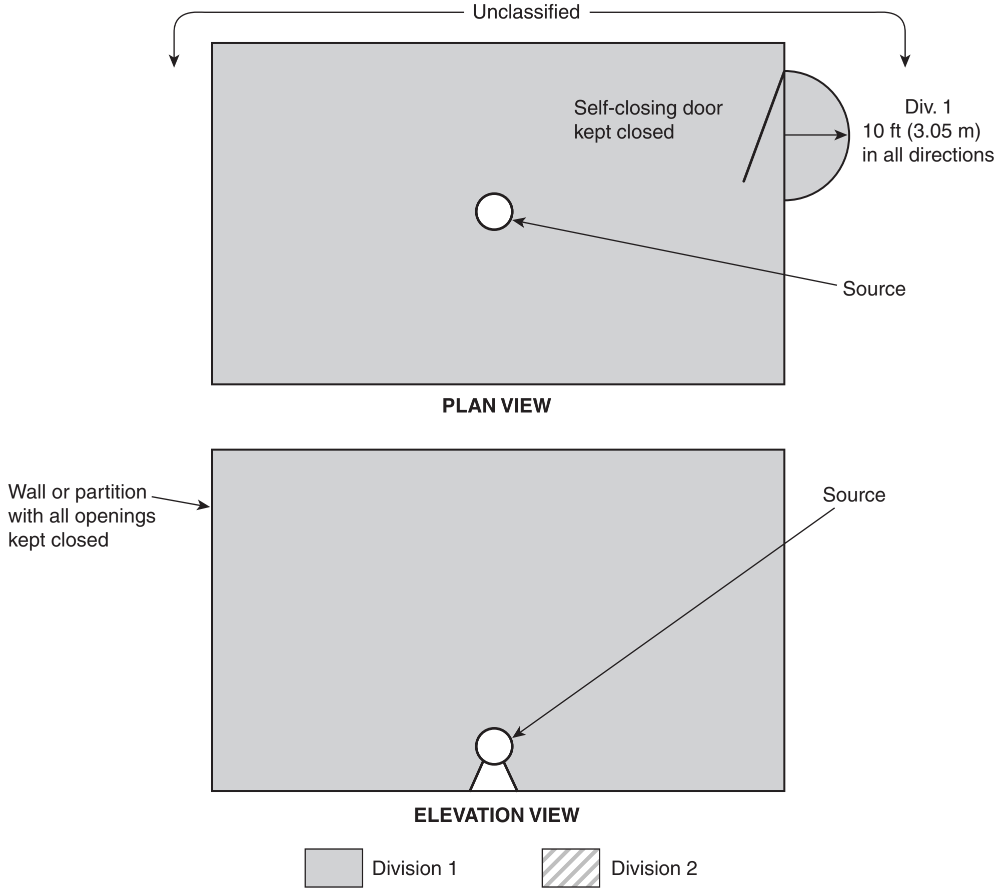
FIGURE 5.8(c) Group F or Group G Dust — Indoor, Unrestricted Area; Operating Equipment Enclosed; Area Classified as a Class II, Division 2 Location.



Description of dust condition

Division 1	Division 2	Unclassified
None	None	Dust layer not apparent. Surface color discernible.

FIGURE 5.8(e) Groups E, F, or G Dusts — Storage Area Bags, Drums, or Closed Hoppers.



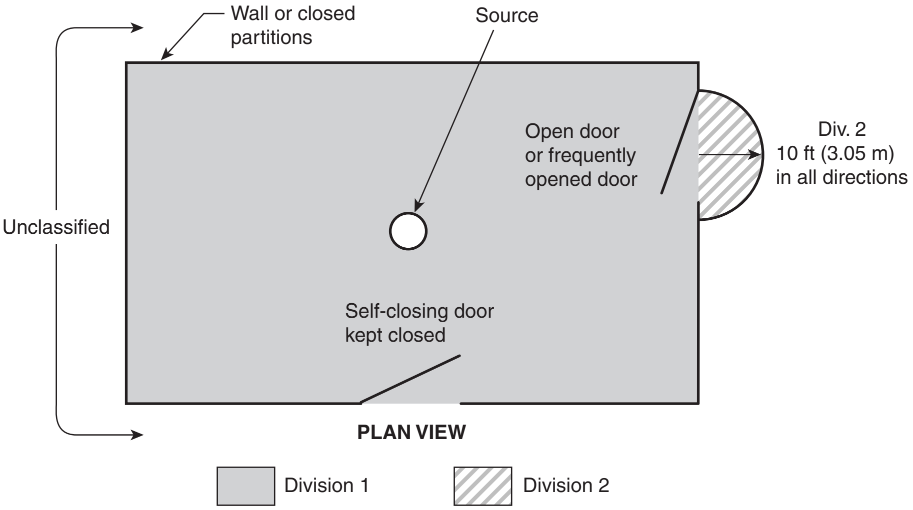
Description of dust condition

Minimize Division 1 cutoff volume and area

Description of equipment/area control

Maximize confinement
Maximize dust control
Maximize housekeeping
See 5.6.5

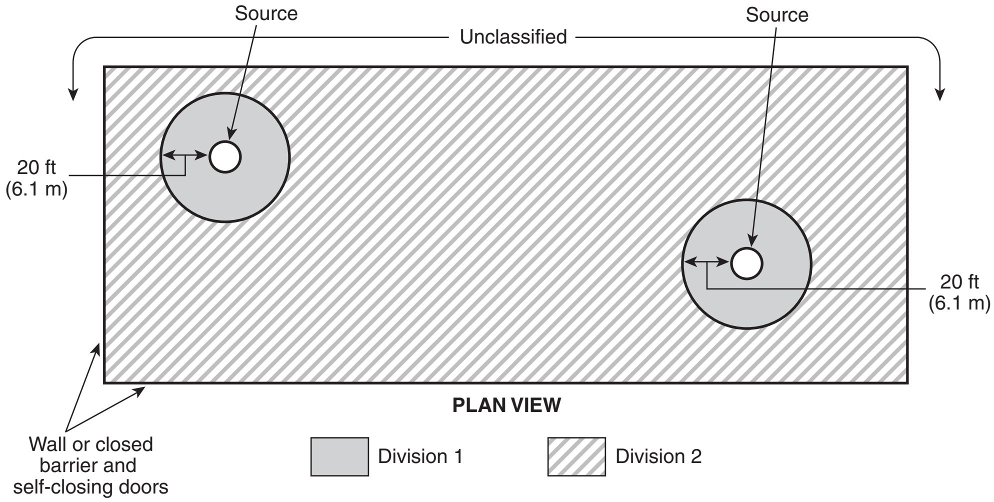
FIGURE 5.8(f) Group E Dust — Indoor, Walled-Off Area; Operating Equipment Enclosed.



Description of dust condition

Division 1	Division 2
Moderate to dense dust cloud or dust layer greater than ⅛ in. (3.0 mm).	No visible dust cloud. Dust layer less than ⅛ in. (3.0 mm) but surface color not discernible.

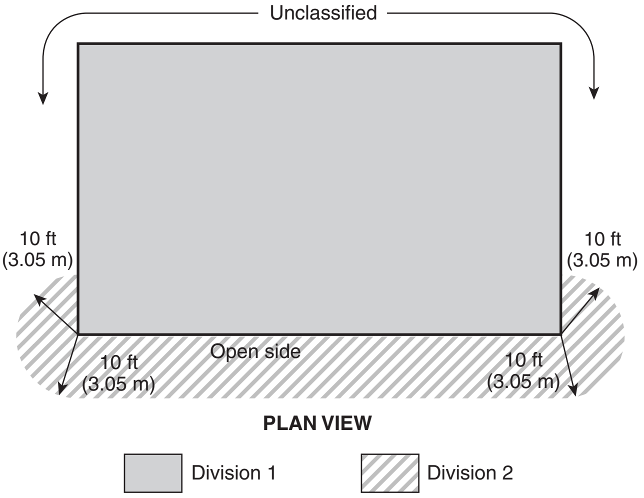
FIGURE 5.8(g) Group F or G — Indoor, Walled-Off Area; Operating Equipment Open or Semi-Enclosed.



Description of dust condition

Division 1	Division 2
Moderate to dense dust cloud. Dust layer greater than ⅛ in. (3.0 mm).	No visible dust cloud. Dust layer less than ⅛ in. (3.0 mm) but surface color not discernible.

FIGURE 5.8(h) Group F or Group G — Indoor, Walled-Off Area; Multiple Pieces of Operating Equipment.



Description of dust condition

Division 1	Division 2
Moderate to dense dust cloud or dust layer greater than ⅛ in. (3.0 mm).	No visible dust cloud. Dust layer less than ⅛ in. (3.0 mm) and surface color not discernible.

FIGURE 5.8(i) Group F or Group G — Indoor, Unrestricted Area; Ventilated Bagging Head.

Annex A Explanatory Material

Annex A is not a part of the recommendations of this NFPA document but is included for informational purposes only. This annex contains explanatory material, numbered to correspond with the applicable text paragraphs.

A.3.3.1 Autoignition Temperature (AIT). See NFPA *Fire Protection Guide to Hazardous Materials*, 2001 edition.

A.3.3.3 Combustible Dust. Prior to the 1981 edition of the *National Electrical Code* (NEC) (1978 and prior editions), all Group E dusts (metal dusts such as aluminum, magnesium, and their commercial alloys) and Group F dusts (carbonaceous dusts such as carbon black, charcoal, or coke dusts having more than 8 percent total volatile materials) were considered to be electrically conductive. As a result, areas containing Group E or Group F dusts were all classified Division 1, as required by the definition of a Class II, Division 1 location. It was only possible to have a Division 2 location for Group G dusts.

The 1984 edition of the NEC eliminated Group F altogether. Carbonaceous dusts with resistivity of less than 10^5 ohm/cm were considered conductive and were classified as Group E. Carbonaceous dusts with resistivity of 10^5 ohm/cm or greater were considered nonconductive and were classified as Group G. This reclassification allowed the use of Group G, Division 2 electrical equipment for many carbonaceous materials.

The 1987 edition of the NEC reinstated Group F because the close tolerances in Group E motors necessary for metal dusts are unnecessary for conductive carbonaceous dusts, and the low temperature specifications in Group G equipment necessary for grain, flour, and some chemical dusts are unnecessary for nonconductive carbonaceous dusts. This imposed an unwarranted expense on users.

This change allowed the use of Group F, Division 2 electrical equipment for carbonaceous dust with a resistivity greater than 10^5 ohm/cm.

The problem with this work was that the resistivity value, a number that related to the dust's ability to conduct an electric current, was not a constant and varied considerably based on dust particle size and extent of oxidation, the moisture content, voltage applied, temperature, and test apparatus and technique. No standardized test method for the resistivity value considering long-term environmental effects has been developed. Finally, the resistivity value is not directly related to the explosion hazard.

A.3.3.6 Explosion Severity. See A.3.3.9, Ignition Sensitivity.

A.3.3.9 Ignition Sensitivity. The U.S. Bureau of Mines has defined ignition sensitivity and explosion severity as follows:

$$\text{Explosion severity} = \frac{(P_{\max} \times P)_2}{(P_{\max} \times P)_1}$$

$$\text{Ignition sensitivity} = \frac{(T_c \times E \times M_c)_1}{(T_c \times E \times M_c)_2}$$

where:

$P_{\max}$ = maximum explosive pressure
P = maximum rate of pressure rise
T_c = minimum ignition temperature
E = minimum ignition energy
M_c = minimum explosive concentration

Subscript 1 refers to the appropriate values for Pittsburgh seam coal, the standard dust used by the U.S. Bureau of Mines.

Subscript 2 refers to the values for the specific dust in question.

Note that units must be consistent in both numerators and denominators.

A.4.1.2 Article 500 also defines two other hazardous (classified) locations: Class I and Class III. In a Class I hazardous (classified) location, the combustible material present is a flammable gas or vapor. In a Class III hazardous (classified) location, the combustible material present is an ignitible fiber or flying. This recommended practice covers Class II hazardous (classified) locations.

A.4.2.2 The presence of flammable gas in a combustible dust cloud drastically reduces the ignition energy. The flammable gas need not be present in amounts sufficient to reach the lower flammable limit (considering the gas phase alone) to exhibit this phenomenon.

A.4.3 Open flames and welding and cutting operations have far more energy and heat than most electrical fault sparks and arcs and are quite capable of igniting dusts. Hot surfaces such as those in some heaters, or those caused by continuous friction, can also have sufficient heat to ignite dusts. Such sources of ignition therefore should be carefully controlled.

A.4.3.1.2 When subjected to heat, dusts of thermosetting plastics, such as phenol formaldehyde resins, tend to polymerize ("set up") and become hard. Continued heat buildup in the polymerized material ultimately leads to carbonization (degradation) of the material and a significantly lower ignition temperature. Although this phenomenon is well known, there is no standardized test to define the precise parameters. Nonplastic materials such as sugar, cornstarch, and dextrine also carbonize and ignite at lower-than-expected temperatures.

A.4.5.2 The materials, and their group classifications, listed in Table 4.5.2, were taken from NMAB 353-3, *Classification of Combustible Dusts in Accordance with the National Electrical Code*, published by the National Academy of Sciences. Dusts having ignition sensitivities equal to or greater than 0.2, or explosion severities equal to or greater than 0.5, are listed. Dusts with explosibility parameters that fall below these limits are generally not considered to be significant explosion hazards and, therefore, are not included in this table. Selection of electrical equipment for dusts that sublime or melt below the operating temperature of the equipment requires additional consideration of the properties of the specific dust. Electrical equipment evaluated and found acceptable for use in the presence of dusts might not be acceptable when exposed to molten material.

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

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

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

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

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

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

$$\frac{0.1\text{ ft}^3}{100\text{ ft}^2}=0.001\text{ ft}=0.012\text{ in. }\left(\tfrac{1}{84}\text{ in. thick}\right)$$

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

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

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

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

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

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

Table A.5.2.2(b) Dust Thickness

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