

NFPA® 499

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

2013 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

2013 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, and acted on by NFPA at its June Association Meeting held June 11–14, 2012, in Las Vegas, NV. It was issued by the Standards Council on August 9, 2012, with an effective date of August 29, 2012, and supersedes all previous editions.

This edition of NFPA 499 was approved as an American National Standard on August 29, 2012.

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 the accepted practices of 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 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 to *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 on Electrical Equipment in Chemical Atmospheres entered NFPA 499 into the November 2003 revision cycle. The 2004 edition was significantly revised and reorganized to conform with the 2003 *Manual of Style for NFPA 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 contained in NFPA 70. To ensure correlation with revisions to the 2008 NEC, the Technical Committee on Electrical Equipment in Chemical Atmospheres was granted permission by the NFPA Standards Council to enter into a three-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 is a complete revision to update references and extracted text. As a result of updating ASTM references, the 2010 edition of ASTM E 1226, *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 the document. These criteria were eliminated because ASTM E 1226 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, has been added.

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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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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.

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. Extracted text may be edited for consistency and style and may include the revision of internal paragraph references and other references as appropriate. 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 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, *National Electrical Code*.

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, *National Electrical Code*.

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 does not address the criteria for classifying locations in accordance with Article 506 of NFPA 70, *National Electrical Code*.

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 agricultural grain-handling facilities except where grain dust is used in a chemical reaction or mixture.

1.3.4 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.

1.3.5 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 the following NFPA standards:

- (1) NFPA 36, *Standard for Solvent Extraction Plants*
- (2) NFPA 61, *Standard for the Prevention of Fires and Dust Explosions in Agricultural and Food Processing Facilities*
- (3) NFPA 68, *Standard on Explosion Protection by Deflagration Venting*
- (4) NFPA 69, *Standard on Explosion Prevention Systems*
- (5) NFPA 70, *National Electrical Code*
- (6) NFPA 484, *Standard for Combustible Metals*
- (7) NFPA 654, *Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids*
- (8) NFPA 655, *Standard for Prevention of Sulfur Fires and Explosions*
- (9) NFPA 664, *Standard for the Prevention of Fires and Explosions in Wood Processing and Woodworking Facilities*



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*, 2009 edition.

NFPA 61, *Standard for the Prevention of Fires and Dust Explosions in Agricultural and Food Processing Facilities*, 2013 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*®, 2011 edition.

NFPA 484, *Standard for Combustible Metals*, 2012 edition.

NFPA 654, *Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids*, 2013 edition.

NFPA 655, *Standard for Prevention of Sulfur Fires and Explosions*, 2012 edition.

NFPA 664, *Standard for the Prevention of Fires and Explosions in Wood Processing and Woodworking Facilities*, 2012 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 D 3175, *Standard Test Method for Volatile Matter in the Analysis Sample of Coal and Coke*, 2011.

ASTM E 11, *Standard Specification for Wire Cloth and Sieves for Testing Purposes*, 2009.

ASTM E 1226, *Standard Test Method for Explosibility of Dust Clouds*, 2010.

ASTM E 1491, *Standard Test Method for Minimum Autoignition Temperatures of Dust Clouds*, 2006.

ASTM E 2021, *Standard Test Method for Hot-Surface Ignition Temperature of Dust Layers*, 2009.

2.3.2 ISO Publications. International Organization for Standardization, 1, rue de Varembe, Case postale 56, CH-1211 Genève 20, Switzerland.

ISO 6184–1, *Explosion protection systems — Part 1: Determination of explosion indices of combustible dust in air*, 1985.

2.3.3 Other Publications.

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

2.4 References for Extracts in Recommendations Sections.

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

NFPA 70®, *National Electrical Code*®, 2011 edition.

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. Finely divided solid particles that present a dust fire or dust explosion hazard when dispersed and ignited in air.

3.3.4 Combustible Dust Groups. Combustible dusts are addressed in the *National Electrical Code*, in Articles 500 and 502, and 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.

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

3.3.5* Hybrid Mixture. A mixture of a flammable gas at greater than 10 percent of its lower flammable limit with either a combustible dust or a combustible mist. [68, 2007]

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.

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

3.3.8 Unclassified Locations. Locations determined to be neither Class I, Division 1; Class I, Division 2; Class I, Zone 0; Class I, Zone 1; Class I, Zone 2; Class II, Division 1; Class II, Division 2; Class III, Division 1; Class III, Division 2; Zone 20; Zone 21; Zone 22; or any combination thereof. [70, 2011]

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

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*

- (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(s) 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, National Electrical Code*, 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 Combustible Dust Testing.

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

4.2.2 Combustible Dust Cloud Explosibility Testing.

4.2.2.1 ASTM E 1226, *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

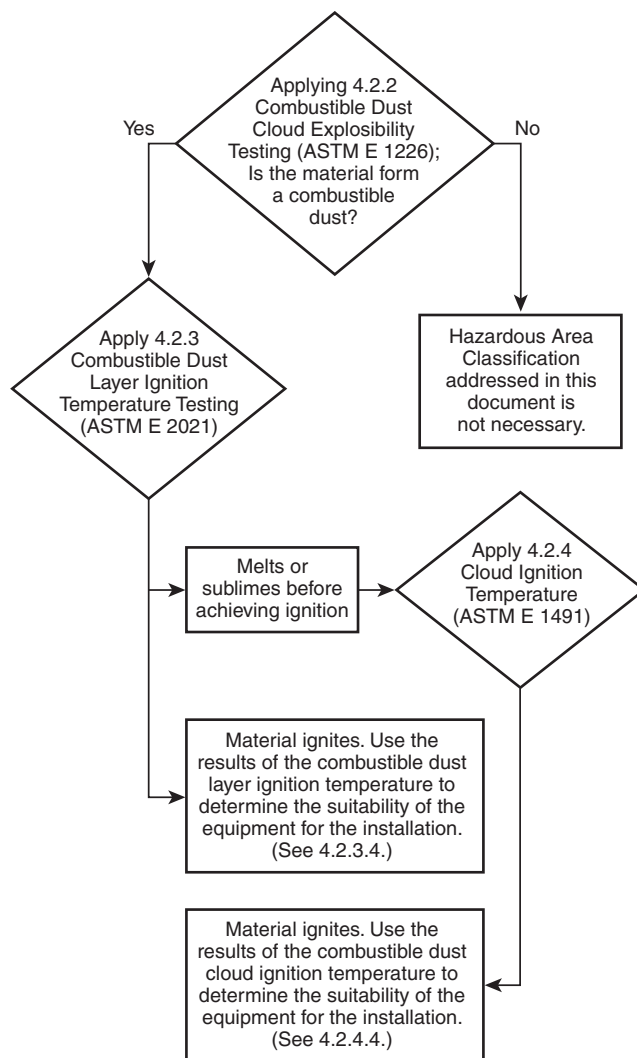


FIGURE 4.2.1 Material Form Testing.

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.

4.2.2.2 If either concentration tested under 4.2.2.1 equals or exceeds the ASTM E 1226 maximum attained pressure criteria, the sample is conditionally a combustible dust.

4.2.2.3 If both concentrations tested under 4.2.2.1 are less than the ASTM E 1226 maximum attained pressure criteria, the sample is likely not a combustible dust.

4.2.3 Combustible Dust Layer Ignition Temperature Testing.

4.2.3.1 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.

4.2.3.2 The ASTM E 2021, *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.

4.2.3.3 If the anticipated material form layer thickness is greater than 12.7 mm (½ in.), the ASTM E 2021 test would be performed at this greater thickness to determine the appropriate temperature.

4.2.3.4* 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.

4.2.3.5 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.

4.2.4 Combustible Dust Cloud Ignition Temperature Testing.

4.2.4.1 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.

4.2.4.2 If the material form sample melts below 450°C (842°F), another sample of the material form should be tested in accordance with ASTM E 1491, *Standard Test Method for Minimum Autoignition Temperatures of Dust Clouds*, to determine the cloud ignition temperature.

4.2.4.3* 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, National Electrical Code*, 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, National Electrical Code*, 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.

[70:500.5(C)(1)]